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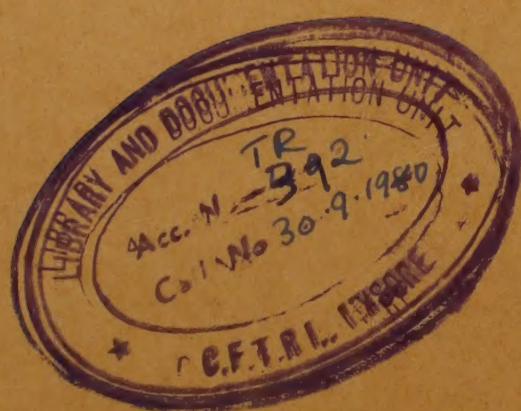
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Tropical Products Institute

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**The market for mango products
with particular reference to
the United Kingdom**





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It specializes in post-harvest problems and will be pleased to answer requests for information and advice.

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NOTE

All large quantities in this report are expressed in metric tons. (One metric ton = 1000 kg = 2204 lb).

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Summary and Conclusions

SUMMARY AND CONCLUSIONS

1. The mango is available in more processed forms than any other minor tropical fruit. Products derived from it include mango slices in brine, canned mangoes in syrup, mango juice, pulp, nectar, flour, jam, dried slices and an assortment of various mango based pickles, chutneys and sauces.
2. The main disadvantage of the mango as a source of fruit based products is the erratic nature of the crop. However both India and South Africa, two of the world's leading producers, are planning increased production.
3. India is by far the world's most important producer and exporter of mango products, followed by Jamaica and South Africa. Other countries currently producing certain of these products include Mexico, China, Taiwan, Pakistan, Australia, Ceylon, Guatemala, Venezuela, Haiti and Cuba. The United Kingdom is an important producer of mango chutneys, manufactured from imported brined slices, which are sold both on the domestic and European markets.
4. Neither total world production nor trade figures are available for any of the products considered in this report due to the dearth of related national statistics.
5. Total Indian exports of mango products amounted to approximately 11,150 tons in 1969/70. In 1969 Jamaica exported 556 tons, and South Africa's world sales probably amount to about 200 tons per annum.
6. The world market can be divided into five principal areas: the United Kingdom, the USSR, the Middle East, the EEC and Scandinavia, and North America.
7. The United Kingdom and the Middle East are the oldest established markets and are generally more familiar with the mango and its products than the others. The EEC and Scandinavia and North America are smaller and more recently established markets, but are exhibiting substantial growth in terms of direct imports from producing countries. The USSR is unique in that the pattern and volume of its trade is largely dictated by trade agreements and currency payment schemes; on this basis, however it has become (through its intake of mango juice) the major world market for mango products.
8. Excluding trade in mango juice (see paragraph 12 below) the **United Kingdom** provides the most substantial and diverse market for mango products, imports amounting to about 3,000 tons in 1969/70. This is due to (a) its considerable immigrant population, and (b) the fact that a sizeable section of the British people has lived and worked overseas, particularly in the tropics, and has thus become familiar with the mango and its products.
9. India is the major supplier to the United Kingdom, followed by Jamaica and South Africa. Very limited quantities are also imported from China, Mexico, Australia, Pakistan and Ceylon.

10. The immigrant community is an important outlet, and for some products — eg mango flour, dried slices, jam, etc. — the only outlet. However recent legislation is limiting the number of new immigrants entering the United Kingdom, which will undoubtedly reduce market expansion prospects, especially as sales saturation point appears to have already been reached amongst the present immigrant population.

11. The major restraints on the expansion of sales to the rest of the community in the United Kingdom are lack of familiarity with the mango and its products, combined with high retail prices.

12. In 1969/70 the **USSR** was the largest single market, importing 6,367 tons of juice and 115 tons of other products from India. This represents more than double the United Kingdom's total imports of all mango products from all sources in that year. The total was also however three times more by weight than in any previous year, but this does not necessarily portend a future demand pattern, especially as trade based on bilateral trade agreements tends to be unpredictable.

13. The **Middle East** market, as defined in this report, comprises Iraq, Saudi Arabia, Kuwait, Bahrein, Muscat, Qatar and Trucial Oman, South Yemen and Somalia. Supplies are obtained principally from India. Indian exports to this market have expanded steadily from about 600 tons in 1965/66 to over 1,500 tons in 1969/70.

14. Mango juice is the most important commodity imported into the Middle East, accounting for more than half the total imports each year, and as much as 84% in 1969/70; mango pickles are second in importance. Sales of juice have been expanding in Bahrein and Qatar/Trucial Oman; sales of pickles have increased in Kuwait and remained steady in Iraq. Since mango products are already familiar to Middle Eastern countries a new supplier would not have to promote unknown products.

15. The **EEC and Scandinavia** are comparatively new markets for mango products. Imports have risen from 94 tons in 1965/66 to 267 tons in 1969/70, showing the market to be in an expansionary stage, though starting from a low base.

16. Imports of mango chutney predominate in this area, accounting for well over two thirds of the total. In the earlier years the United Kingdom supplied over 80% of the demand but direct imports from India have since become more important.

17. Germany is the major national outlet in this area for mango chutney, followed by the Netherlands and Denmark.

18. Other mango products have made little impact in the EEC and Scandinavia, although Germany has imported limited quantities of juice, slices in brine, slices in syrup and purees, pastes etc., albeit rather spasmodically, and the Netherlands has made occasional imports of mangoes in syrup.

19. Various mango products are imported into **North America**, ie the United States and Canada. India and Jamaica are the main known suppliers, though it is probable that the United States also receives shipments from Mexico, Guatemala, Taiwan, Haiti and Venezuela.

20. The major North American imports are mango chutneys and pickles, but combined intake has remained steady at around 200 tons per annum over recent years, with the United States accounting for about three quarters of the total.

21. The next most important items are mangoes in syrup and slices in brine, both from Jamaica. The relative volume of each product is not known, however, as they are not differentiated in the trade returns, but an overall upward trend in imports is apparent.

22. Trade has been known in other mango products with North America, although in only one instance has it reached a level of more than 3 tons in any single year.

23. The structure of the trade in the United Kingdom is described in some detail. Mango slices in brine are primarily imported direct by the larger processing companies; the other items, which are largely goods for direct consumption, are handled by importers who frequently discharge the wholesale function as well, selling direct to retailers and restaurateurs. However the number of firms involved in the trade is small owing to (a) the limited turnover volume and (b) the specialist nature of most final outlets.

24. Margins on mango products, as they apply at each stage of the trade chain, tend to be higher than on more substantially traded items. The importer's mark-up is usually between 5-10%, that of the wholesaler between 10-15%, whilst the retailer usually takes upwards of 25%.

25. Relevant tariffs applying to trade with the United Kingdom, the EEC and the United States are shown. Produce from Commonwealth countries and South Africa enters the United Kingdom duty free; most items from non-Commonwealth sources attract a 10% *ad valorem* duty; slices in brine or syrup, and pulp, 15%, and dried slices 5%; however new preferences for developing countries came into force on 1.1.72 granting these countries duty free entry into the United Kingdom for most products. EEC full duties range from free entry for mango chutneys to 30% *ad valorem* for jams, jellies, etc.; the canned fruit rate is 24% (for retail size cans) plus an additional levy on the sugar content; preferential rates for developing countries were introduced on 1.1.71 involving reductions in most cases of 3 or 4%. Four *ad valorem* rates apply to United States imports, ranging from 3% on juice to 7.5% on sauces. Duty levied on prepared and preserved fruit stands at 3.75 cents per lb.

26. Appropriate notes on quality appear in the report, with attention drawn to certain preferences within specific markets.

27. Owing to the multiplicity of products with which the report deals discussions of prospects for the separate commodities in different countries appear in appropriate places, and have not been drawn together in one section. However, the situation in the United Kingdom can be summarised as follows:

- a. India is the only known exporter of dried mango slices, and the United Kingdom is the only significant market. Imports are limited (ranging from 1 to 46 tons per annum) and increased trade is unlikely, due in part to dehydration problems,
- b. United Kingdom imports of mango juice are at a low level (19 tons per annum average over the last five years), are consumed entirely by those of Indian or Pakistani descent, and are not expected to increase,
- c. imports of pickles (unsweetened and highly spiced) go primarily to immigrant consumers and restaurants; the increased rate of consumption registered over the last five years is likely to level off, a decreased rate of sales expansion direct to the immigrant community more than outweighing probable increased demand from the catering trade,
- d. chutney consumption is considered likely to increase as its flavour is blander than that of pickles, and hence it has a wider appeal; whether further demand will benefit suppliers of ready-made chutneys, rather than those of brined slices, is not clear, though the latter are considered to be the more likely beneficiaries,
- e. canned mangoes in syrup have three distinct outlets — the "Indian", "West Indian" and "British" market sectors. It is concluded that the "British" sector, (which generally prefers a less sweet product to that favoured by the others) offers the widest potential for future growth, although stimulation of this market may prove difficult and expensive. However, demand may receive an indirect but significant stimulus from increased sales of the fresh fruit if, as is a possibility, fresh mangoes are able to be transported satisfactorily by sea, becoming cheaper and more readily available in consequence,

- f. imports of mango pulp into the United Kingdom have increased substantially since 1965/66; sales however are almost entirely to the "Indian" sector of the market and for this reason prospects are limited owing to new restrictions on immigration now in force. A specialist ice-cream manufacturer and retailer has, however, recently launched a mango-flavoured product, using pulp as the fruit flavour base, but the firm's requirements at present are small,
- g. dried slices (see a. above), flour and jam are all very minor items, and even large growth rates in imports, which are not forecast, would have little significance on total imports.

28. To summarise prospects in markets other than the United Kingdom it can be said that:

- a. the USSR's trade in mango juice is very substantial, a particularly large increase (x 3) having been recorded in 1969/70; however predictions as to future trade are impossible to make,
- b. in the Middle East the main commodity is mango juice, followed by pickles; the major individual markets are Kuwait, Qatar and Trucial Oman and Saudi Arabia. Although trade has fluctuated, mango juice appears to have the best growth prospects,
- c. the outlook in the EEC and Scandinavia looks brightest for chutneys, notably in Germany, but also in Sweden and Denmark: Germany should also offer limited further scope for mango juice. Imports of other items to this area are likely to remain static.
- d. the North American market is supplied by several producers, though only details of trade with Jamaica and India are known. The United States accounts for 75%+ of this market's imports from India, the bulk of which consists of chutneys, for which no consequential improvement in sales is foreseeable. However, imports from Jamaica of slices in brine and syrup have recently shown substantial gains, though actual quantities of each product are not separately disclosed in the official trade statistics. Imports of chutneys may increase slightly, but sales of other products (flour and dried slices) are likely to remain insignificant.

SOMMAIRE ET CONCLUSIONS

1. La mangue se rencontre sous plus de formes traitées que tout autre fruit tropical mineur. Les produits qui en sont dérivés comprennent les tranches de mangue dans la saumure, les mangues au sirop en boîte, le jus, la pulpe, le nectar, la farine, la confiture, les tranches desséchées de mangue et un assortiment de marinades au vinaigre, de chutneys et de sauces à base de mangue.

2. L'inconvénient principal de la mangue en tant que source de produits à base de fruit, est la nature irrégulière de la récolte. Cependant, l'Inde et l'Afrique du Sud, deux des pays producteurs mondiaux les plus importants, envisagent une production plus importante.

3. L'Inde est de beaucoup le pays producteur et exportateur de produits à base de mangue mondialement le plus important, suivi par la Jamaïque et l'Afrique du Sud. Les autres pays à l'heure actuelle producteurs de produits à base de mangue comprennent le Mexique, la Chine, T'Ai-Wan, le Pakistan, l'Australie, Ceylan, Guatemala, le Venezuela, Haïti et Cuba. Le Royaume Uni est un producteur important de chutneys de mangue qui sont fabriqués avec les tranches saumurées importées et sont vendus sur les marchés domestique et européen.

4. La production mondiale et les chiffres d'affaires pour les produits considérés ne sont pas fournis dans ce rapport à cause du manque de statistiques des pays en question.

5. L'exportation totale de l'Inde pour les produits à base de mangue s'élevait à environ 11 150 tonnes en 1969/1970. En 1969 l'exportation de la Jamaïque s'élevait à 556 tonnes, et celle de l'Afrique du Sud, probablement à environ 200 tonnes par an.
6. Le marché mondial peut être divisé en cinq zones principales: le Royaume Uni, l'URSS, le Moyen Orient, la CEE et la Scandinavie, et l'Amérique du Nord.
7. Le Royaume Uni et le Moyen Orient sont les marchés de mangue les plus anciens et sont en général plus familiers que les autres avec la mangue et ses produits. La CEE et la Scandinavie et l'Amérique du Nord sont plus petits et d'établissement plus récent, mais présentent une tendance d'accroissement importante en termes d'importations directes des pays producteurs. L'URSS est unique parce que le type et le volume de son commerce est dicté en majorité par les traités commerciaux et les arrangements de paiement financiers; à partir de là, elle est devenue (grâce à ses achats de jus de mangue) le marché mondial principal de produits à base de mangue.
8. A l'exception du commerce en jus de mangue (voir paragraphe 12 ci-dessous) le **Royaume Uni** fournit les marchés les plus divers et les plus importants pour les produits à base de mangue, ses importations s'élevaient à environ 3 000 tonnes en 1969/1970. Ceci est à cause de (a) sa population immigrante considérable et (b) le fait qu'une partie importante de ses habitants a vécu et travaillé à l'étranger, en particulier sous les tropiques, et s'est familiarisée avec la mangue et ses produits.
9. L'Inde est le fournisseur principal du Royaume Uni, suivie par la Jamaïque et l'Afrique du Sud. Des quantités très limitées sont aussi importées de Chine, du Mexique, du Pakistan et de Ceylan.
10. La communauté immigrante est une consommatrice importante, et pour certains produits, par exemple farine de mangue, tranches desséchées, confiture, etc. — la seule consommatrice. Cependant les lois récentes limitent l'immigration dans le Royaume Uni, ce qui va réduire sans aucun doute les perspectives d'expansion du marché, spécialement comme le point de saturation de la vente paraît être déjà atteint chez la population immigrante.
11. L'entrave principale au développement des ventes au reste de la population du Royaume Uni, est le manque de connaissances de la mangue et de ses produits, combiné aux prix de vente élevés.
12. En 1969/70, l'URSS était le marché unique le plus important avec une importation de l'Inde de 6 367 tonnes de jus et 115 tonnes d'autres produits. Ceci représente plus du double des importations totales de produits à base de mangue importés par le Royaume Uni de toutes les sources au cours de cette même année. Le total en poids était cependant trois fois plus élevé que celui de toutes les années précédentes, mais ceci n'augure pas nécessairement le genre des demandes futures, d'autant plus que le commerce basé sur les traités commerciaux bilatéraux tend à être imprévisible.
13. Le marché du **Moyen Orient**, ainsi qu'il est défini dans ce rapport, comprend l'Iraq, l'Arabie Saoudite, Kuwait, Bahrain, Mascate, Katar et l'Oman Trucial, le Yémen du Sud et la Somalie. L'approvisionnement vient principalement de l'Inde. Les exportations de l'Inde vers ce marché ont augmenté d'environ 600 tonnes en 1965/66 à plus de 1 500 tonnes en 1969/70.
14. Le jus de mangue est la denrée la plus importante importée par le Moyen Orient, s'élevant à plus de la moitié des importations totales annuelles, et allant jusqu'à 84% en 1969/70; les marinades de mangue occupent le second rang d'importance. Les ventes de jus ont augmenté à Bahrain et à Katar/Oman Trucial; celles de marinades ont augmenté à Kuwait et sont restées stables en Iraq. Comme les produits à base de mangue sont bien connus des pays du Moyen Orient, un nouveau marchand n'aurait pas à lancer des produits méconnus.

15. La CEE et la Scandinavie sont des marchés de produits à base de mangue relativement récents. Leurs importations ont augmenté de 94 tonnes en 1965/66 à 267 tonnes en 1969/70, montrant que le marché est en voie d'expansion, bien que parti de très bas.
16. Les importations de chutneys de mangue prédominent, comptant pour beaucoup plus des deux tiers du total. Pendant les premières années, le Royaume Uni fournissait plus de 80% des besoins, mais les importations directes de l'Inde sont devenues depuis plus importantes.
17. L'Allemagne offre dans ce secteur le débouché national le plus important pour le chutney de mangue, suivie par la Hollande et le Danemark.
18. Les autres produits à base de mangue ont eu peu d'impact dans la CEE et en Scandinavie bien que l'Allemagne ait importé des quantités limitées de jus, de tranches saumurées, de tranches au sirop et de compotes, pâtes etc., quoique plutôt spasmodiquement, et la Hollande a quelquefois importé des mangues au sirop.
19. Divers produits à base de mangue sont importés par l'Amérique du Nord, c'est à dire les Etats Unis et le Canada. L'Inde et la Jamaïque sont les deux fournisseurs principaux connus, bien qu'il soit probable que les Etats Unis reçoivent des cargaisons en provenance du Mexique, de Guatemala, de T'Ai-Wan, de Haïti et du Venezuela.
20. Les importations nord américaines les plus importantes sont les chutneys de mangue et les marinades, mais l'arrivée combinée annuelle est restée stable à environ 200 tonnes au cours des années récentes, avec les Etats Unis comptant pour plus des trois quarts du total.
21. Les articles suivants les plus importants sont: les mangues au sirop et les tranches saumurées venant toutes deux de Jamaïque. Cependant, on ne sait pas le volume relatif de chaque produit comme ils ne sont pas différenciés dans les revenus commerciaux, mais on remarque une tendance à la croissance.
22. En Amérique du Nord, on a rencontré du commerce pour d'autres produits à base de mangue, bien que dans un cas seulement celui-ci ait atteint plus de 3 tonnes par an.
23. On décrit en détail la structure du commerce dans le Royaume Uni. Les tranches de mangue saumurées sont importées, en majeure partie, directement par les compagnies alimentaires plus importantes: les autres produits qui sont principalement pour la consommation directe, sont maniés par les importateurs qui en font aussi la vente en gros directement aux commerçants et aux restaurateurs. Cependant, le nombre de compagnies engagées dans ce commerce est faible à cause de (a) le volume faible manié et (b) la nature spécialisée de la plupart des débouchés finals.
24. Les marges sur les produits à base de mangue, comme elles sont applicables à chaque étape de la chaîne commerciale, tendent à être plus importantes que sur des produits commerciaux plus substantiels. La majoration des importateurs est en général de 5 à 10%, celle des grossistes de 10 à 15% alors que les commerçants prennent en général à partir de 25%.
25. On montre les tarifs applicables au commerce avec le Royaume Uni, la CEE et les Etats Unis. Les produits des pays du Commonwealth et de l'Afrique du Sud arrivent dans le Royaume Uni sans droits de douane; la plupart des produits de sources non-commonwealth sont en général majorés de droits de 10%; les tranches saumurées ou au sirop et la pulpe, 15%, et les tranches desséchées 5%; cependant de nouvelles préférences pour les pays en cours de développement entrèrent en vigueur le 1.1.72, accordant à ces pays l'entrée dans le Royaume Uni de la plupart des produits sans droits de douane. Les droits dans la CEE vont de l'entrée libre pour les chutneys de mangue à une majoration de 30% pour les confitures, les gelées etc.; le tarif pour le fruit en boîte est de 24% (pour les boîtes de taille domestique) plus

une levée supplémentaire sur la teneur en sucre; des tarifs préférentiels pour les pays en cours de développement furent introduits le 1.1.71, comprenant des réductions dans la plupart des cas de 3 ou 4%. Quatre tarifs de majoration sont applicables aux importations des Etats Unis, allant de 3% sur le jus à 7,5% sur les sauces. Les droits prélevés sur le fruit préparé et en conserve s'élèvent à 3.75 cents par livre.

26. Des notes applicables à la qualité figurent dans ce rapport avec des remarques sur les préférences au sein de marchés spécifiques.

27. A cause de la multitude des produits dont traite ce rapport, les discussions sur les perspectives de chaque denrée dans les divers pays apparaissent aux endroits appropriés et n'ont pas été rassemblées dans une section. Toutefois, la situation dans le Royaume Uni peut être résumée de la façon suivante:

- a. L'Inde est le seul pays exportateur de tranches de mangue et le Royaume Uni en est le seul marché d'importance. Les importations sont faibles (allant de 1 à 46 tonnes par an) et un essor du commerce est peu probable dû en partie aux problèmes de deshydratation,
- b. Les importations de jus de mangue de Royaume Uni sont faibles (19 tonnes en moyenne par an au cours des cinq dernières années) et sont entièrement consommées par la population d'origine indienne ou pakistanaise, une augmentation n'est pas envisagée,
- c. les importations de marinades (non sucrées et fortement épicées) vont principalement aux consommateurs immigrants et aux restaurants; l'augmentation du taux de consommation enregistré au cours des cinq dernières années va sans doute se stabiliser, une diminution de l'expansion des ventes directement à la communauté immigrante contrebalançant probablement l'augmentation de la demande par la restauration,
- d. On considère que la consommation des chutneys augmentera vraisemblablement, comme leur goût est plus doux que celui des marinades et est donc d'attrait plus répandu, que la demande soit profitable aux fournisseurs de chutneys préparés plutôt qu'à ceux de tranches saumurées, n'est pas clair, bien que ces derniers soient considérés d'en être plus probablement les bénéficiaires,
- e. Les mangues au sirop en boîte ont trois débouchés distincts — les secteurs du marché "indien", "antillais" et "britannique". On considère que le secteur "britannique" (qui en général préfère un produit moins sucré que celui choisi par les autres) offre les plus grandes possibilités d'expansion future, bien que la stimulation de ce marché puisse s'avérer difficile et coûteuse. Cependant, il se peut que la demande reçoive une impulsion, indirecte mais importante, venant des ventes du fruit frais, si, comme il est possible, les mangues peuvent être transportées par bateau de façon satisfaisante, devenant en conséquence moins chères et plus abondantes,
- f. L'importation de pulpe de mangue par le Royaume Uni a beaucoup augmenté depuis 1965/66; les ventes sont cependant presque entièrement au secteur "indien" du marché, et pour cette raison, les perspectives sont limitées à cause des restrictions sur l'immigration maintenant en vigueur. Faisant usage de la pulpe comme base, un fabricant et marchand spécialisé de glaces vient récemment de lancer un produit parfumé à la mangue, mais les demandes de la compagnie sont à l'heure actuelle faibles,
- g. Les tranches desséchées (voir a. ci-dessus), la farine et la confiture sont des produits peu importants, et même une grosse croissance des taux d'importation, qui n'est pas envisagée, aurait très peu de conséquences sur l'importation totale.

28. Afin de résumer les perspectives sur les marchés autres que le Royaume Uni, on peut dire que:

- a. Le commerce en jus de mangue de l'URSS est très important, une grosse augmentation (x 3) en particulier ayant été enregistrée en 1969/70: cependant, il est impossible de prédire le commerce futur,

- b. au Moyen Orient, la denrée principale est le jus de mangue, suivi par les marinades; les marchés individuels les plus importants sont Kuwait, Katar et l'Oman Trucial et l'Arabie Saoudite. Bien que le commerce ait varié, le jus de mangue paraît avoir les perspectives les meilleures,
- c. l'avenir dans la CEE et la Scandinavie a l'air meilleur pour les chutneys, en particulier en Allemagne, mais aussi au Danemark et en Suède: l'Allemagne devrait aussi offrir quelques débouchés pour le jus de mangue. Il est probable que les importations d'autres produits dans ces régions, restent statiques.
- d. Le marché nord américain est approvisionné par plusieurs producteurs, bien que seuls les détails du commerce avec l'Inde et la Jamaïque soient connus. Les Etats Unis sont responsables pour plus de 75% des importations de ce marché de l'Inde, et consistent en gros de chutneys pour lesquels on n'envisage en conséquence aucune amélioration des ventes. Cependant, on a récemment enregistré des gains importants sur les importations de tranches saumurées et au sirop de Jamaïque bien que les quantités de chaque produit ne soient pas données séparément dans les statistiques officielles du commerce. Il est possible que les importations de chutneys augmentent légèrement, mais les ventes des autres produits (farine et tranches desséchées) demeureront probablement sans importance.

RESUMEN Y CONCLUSIONES

1. El mango se encuentra en más formas procesadas que cualquier otro fruto tropical. Productos derivados de él incluyen tajadas de mango en salmuera, mangos envasados en almibar, jugo de mango, pulpa, néctar, harina, dulce, tajadas desecadas y un surtido variado de pickles, chutney y salsas basadas en mango.
2. La desventaja primordial del mango como fuente de productos basados en frutas es la naturaleza errática de su cosecha. Sin embargo, tanto India como Africa del Sud, dos de los líderes mundiales de productores, planean aumentos de producción.
3. El productor y exportador más importante en el mundo, muy por delante de los demás, es India, detrás de ella se encuentran Jamaica y Africa del Sud. Otros países que cuentan con producción de algunos de estos productos incluyen a México, China, Taiwan, Pakistán, Australia, Ceylán, Guatemala, Venezuela, Haiti y Cuba. El Reino Unido es un productor importante de chutneys de mango, manufacturados con tajadas en salmuera importadas, los cuales se venden en ambos mercados el doméstico y el Europeo.
4. No se cuenta con cifras de la producción ni ventas totales mundiales en relación a cualquiera de los productos considerados en este estudio, debido a la escasez de estadísticas nacionales relevantes.
5. El total de exportación de productos de mango desde India llegó a cerca de 11 150 toneladas durante 1969/70. Durante 1969, se exportó desde Jamaica 556 toneladas, y las ventas mundiales desde Africa del Sud pueden sumar a cerca de 200 toneladas anuales.
6. El mercado mundial puede ser dividido en cinco zonas principales: el Reino Unido, la URSS, el Oriente Medio, el Mercado Común Europeo y Escandinavia, y América del Norte.
7. El Reino Unido y el Oriente Medio son los mercados más antiguos establecidos y están generalmente más familiarizados con el mango y sus productos que los demás. El Mercado Común Europeo y Escandinavo así como America del Norte son mercados menores y establecidos más recientemente, pero muestran aumentos substanciales en términos de importación directa desde países productores. La URSS es

única en que el sistema y volumen de su comercio es regido más que nada por acuerdos comerciales y sistemas de pago monetario; sobre esta base sin embargo, ha llegado (a causa de sus compras de jugo de mango) a ser el mayor mercado mundial para productos de mango.

8. Excluyendo al comercio en jugo de mango (véase párrafo 12 abajo), el **Reino Unido** ofrece el mercado más importante y variado para productos de mango, alcanzando sus importaciones a cerca de 3 000 toneladas durante 1969/70. Esto es debido a (a) su considerable población de inmigrantes, y (b) la realidad que un porcentaje elevado del pueblo Británico ha vivido y trabajado en el exterior, especialmente en zonas tropicales, familiarizándose de esta manera con el mango y sus productos.

9. India es el mayor proveedor del Reino Unido, seguido por Jamaica y Africa del Sud. Cantidades muy limitadas se importan también desde China, México, Australia, Pakistán y Ceylán.

10. La comunidad inmigrante es un consumidor importante, y para algunos productos-como ser: harina de mango, tajadas desecadas, dulce, etc. — el único cauce. Sin embargo, regulaciones recientes están limitando la cantidad de nuevos inmigrantes que pueden ingresar al Reino Unido, lo cual indudablemente reducirá las perspectivas de expansión del mercado, especialmente debido a la saturación de ventas que parece ya haberse alcanzado entre la población inmigrante actual.

11. Los impedimentos mayores a la expansión de ventas al remanente de la comunidad en el Reino Unido, son la falta de familiarización con el mango y sus productos combinado con precios elevados en ventas al detalle.

12. Durante 1969/70, la **URSS** fué el mercado unitario más voluminoso, importó 6 367 toneladas de jugo y 115 toneladas de otros productos desde la India. Esto representa más del doble de las importaciones totales del Reino Unido de todos los productos de mango desde todo origen en ese año. El total fué también, sin embargo tres veces mayor por peso que en cualquier año anterior, aunque no indica necesariamente un formato de demanda futuro, especialmente considerando que el comercio basado en acuerdos comerciales bilaterales no tiende a ser pronosticable.

13. El mercado del **Oriente Medio**, como definido en este informe comprende a: Iraq, Arabia Saudita, Kuwait, Bahrein, Muscat, Oman Qatar y Trucial, Yemen del Sud y Somalia. Los suministros se obtienen principalmente desde la India. Las exportaciones desde India a este mercado han aumentado firmemente desde cerca de 600 toneladas durante 1965/66, hasta más de 1 500 toneladas durante 1969/70.

14. Jugo de mango es el producto más importante importado al Oriente Medio, sumando más de la mitad de las importaciones totales de cada año, y llegando a ser el 84% durante 1969/70; le siguen en importancia pickles de mango. Las ventas de jugo han estado en aumento en Bahrein y Oman Qatar y Trucial; las ventas de pickles han aumentado en Kuwait y permanecen firmes en Iraq. Ya que los productos de mango son conocidos en los países del Oriente Medio, un nuevo proveedor no tendrá que hacer promoción de productos desconocidos.

15. El **Mercado Común Europeo y Escandinavia** son mercados comparativamente nuevos para productos de mango. Las importaciones han aumentado desde 94 toneladas durante 1965/66 a 267 toneladas en 1969/70, demostrando que el mercado está en una etapa de expansión, aunque parte desde un nivel bajo.

16. En esta zona predominan las importaciones de chutney de mango, sumando bastante más de los dos tercios del total. Durante años anteriores el Reino Unido suministró más del 80% de la demanda, pero posteriormente las importaciones directas desde India han adquirido la mayor importancia.

17. Alemania es el consumidor nacional mayor en esta zona para chutney de mango, seguida por los Países Bajos y Dinamarca.

18. Otros productos de mango han hecho poco impacto en el Mercado Común Europeo y Escandinavia, aunque Alemania ha importado cantidades limitadas de jugo, tajadas en salmuera, tajadas en almíbar, puré, pastas, etc., siempre en forma espasmódica, y los Países Bajos han efectuado importaciones ocasionales de mangos en almíbar.

19. Se importan varios productos de mango en **Norte América**, vale decir Estados Unidos y Canadá. Los proveedores principales conocidos son India y Jamaica, aunque es probable que los Estados Unidos recibe también embarques desde Méjico, Guatemala, Taiwán y Venezuela.

20. Las importaciones mayores a Norte América son chutney y picles de mango, pero el ingreso combinado se ha mantenido firme en cerca de 200 toneladas anuales durante los últimos años, correspondiéndole a Estados Unidos cerca de las tres cuartas partes de la cifra total.

21. Los productos que le siguen en importancia son mangos en almíbar y tajadas en salmuera, ambos originados en Jamaica. El volumen relativo de cada producto se desconoce, sin embargo, ya que no se diferencian en los resultados comerciales, pero es aparente una tendencia general ascendente en las importaciones.

22. Se ha conocido comercio de otros productos de mango con América del Norte, aunque en un sólo caso ha llegado al nivel de más de 3 toneladas en cualquier año individual.

23. La estructura del comercio en el Reino Unido se describe en algún detalle. Tajadas de mango en salmuera se importan principalmente en forma directa por las compañías mayores de procesamiento: los demás productos, que son mayormente mercaderías para consumo directo, son comerciados por importadores que frecuentemente cumplen también la función de mayoristas, con ventas a minoristas y restaurantes. Sin embargo, el número de firmas involucradas en el comercio es pequeño debido a (a) el volumen limitado de giro y (b) la naturaleza especializada de la mayoría de los mercados finales.

24. Los márgenes sobre productos de mango, como aplicados en cada etapa de la línea de ventas, tienden a ser mayores que en otros artículos de comercialización más voluminosa. El margen agregado por el importador es normalmente entre el 5-10%, el del mayorista del 10-15%, mientras que el minorista obtiene normalmente más del 25%.

25. Las tarifas pertinentes aplicadas al comercio con el Reino Unido, el Mercado Común Europeo y los Estados Unidos son indicados. Producción de los países del Commonwealth Británico y Africa del Sud ingresa al Reino Unido sin recargos; la mayor parte de los artículos de origen fuera del Commonwealth sufre una tasa del 10% ad valorem; tajadas en salmuera o en almíbar y pulpa el 15%, y tajadas secas el 5%; sin embargo nuevas tasas preferenciales para países en desarrollo entraron en vigencia el 1.1.72, otorgando el ingreso sin recargos para la mayoría de estos productos desde estos países. Las tasas plenas del Mercado Común Europeo oscilan desde ingreso sin recargos para chutney de mango hasta el 30% ad valorem sobre dulces, jaleas, etc.; la tasa para fruta envasada es el 24% (para envases tamaño minorista) más una tasa adicional sobre el contenido de azúcar; se introdujeron tasas preferenciales para países en desarrollo el 1.7.71, involucrando reducciones del 3 o 4% en la mayoría de los casos. En los Estados Unidos se aplican cuatro tasas ad valorem a las importaciones, oscilando desde el 3% sobre jugo al 7,5% sobre salsas. El recargo aplicado sobre fruta preparada y preservada se eleva a 3,75 centavos por libra.

26. En este informe se ofrecen notas apropiadas sobre calidad, enfocando atención a ciertas preferencias dentro de mercados específicos.

27. Debido a la multitud de productos con que trata el informe, comentarios de las posibilidades de los productos separados en los distintos países aparecen en los lugares adecuados, sin haberse reunido todos en una sección. Sin embargo, la situación en el Reino Unido puede resumirse como detallado a continuación:

- a. India es el único exportador conocido de tajadas desecadas de mango, y el Reino Unido es el único mercado significativo. Las importaciones son limitadas (oscilando de 1 a 46 toneladas anuales) y es improbable aumento de comercio, debido en parte a problemas de deshidratación,
- b. las importaciones del Reino Unido de jugo de mango están a un nivel bajo (19 toneladas anuales de promedio sobre los últimos cinco años), su consumo es íntegramente por personas de descendencia India o de Pakistán, sin anticiparse aumentos en el consumo,
- c. las importaciones de pickles (sin endulzar y muy condimentados) se destinan principalmente a consumidores y restaurantes de origen inmigrante; el aumento de consumo en los valores registrados sobre los últimos cinco años probablemente se nivelará, una disminución del promedio de ventas en aumento directamente a la comunidad inmigrante restando efectivamente del aumento probable de la demanda del comercio gastronómico,
- d. el consumo de chutney se considera con posibilidad de aumento ya que su sabor es más suave que el de los pickles, teniendo por ello más atracción; mientras que si la mayor demanda beneficiará a proveedores de chutney manufacturado, más que a proveedores de tajadas en salmuera, no es evidente, aunque los últimos se consideran como los beneficiarios más probables,
- e. mangos envasados en almíbar tiene tres sectores de venta definidos — los sectores “Indio”, “Indio Occidental (Caribe)” y “Británico”. Se concluye que el sector “Británico”, (el cual generalmente prefiere al producto menos dulce que el favorecido por los demás) ofrece el potencial más amplio para desarrollo futuro, aunque la estimulación de este mercado puede resultar difícil y caro. Sin embargo, la demanda puede recibir un estímulo indirecto pero significativo del aumento de las ventas de fruta fresca si, como es posible, se pueden transportar satisfactoriamente mangos frescos por vía marítima, resultando más baratos y de mejor disponibilidad como consecuencia,
- f. importaciones de pulpa de mango al Reino Unido han aumentado substancialmente desde 1965/66; las ventas son, sin embargo, casi completamente al sector “Indio” del mercado y es por esta razón que las posibilidades son limitadas, debido a las restricciones de inmigración en vigor actualmente. Un fabricante y minorista de cremas heladas, sin embargo, ha lanzado recientemente un producto con sabor a mango, utilizando pulpa como base del sabor de la fruta, pero las necesidades de este fabricante son actualmente pequeñas,
- g. tajadas desecadas (vease a. anteriormente), harina y dulce son todos artículos de menor cuantía, y aún grandes aumentos de importación, que no se pronostican, tendrían poco efecto sobre las importaciones totales.

28. En resumen las perspectivas en mercados fuera del Reino Unido pueden ser expresadas como:

- a. El comercio de la URSS en jugo de mango es bastante significativo, habiéndose registrado un aumento particularmente importante (x 3) durante 1969/70; sin embargo, es imposible hacer pronóstico sobre las ventas futuras,
- b. en el Oriente Medio la venta principal es jugo de mango, seguida por pickles; los mayores mercados individuales son Kuwait, Oman Qatar y Trucial y Arabia Saudita. Aunque hay fluctuación de comercio, el jugo de mango parece tener las mejores perspectivas de comercialización,

- c. el panorama en el Mercado Común Europeo y Escandinavia parece más brillante para chutney, especialmente en Alemania, pero también en Suecia y Dinamarca; Alemania debería también ofrecer más posibilidades para jugo de mango. Las importaciones de los demás artículos en esta zona tienen posibilidades de mantenerse niveladas,
- d. el mercado Norteamericano es suministrado por varios productores, aunque sólo se conocen detalles del comercio con Jamaica y la India. Los Estados Unidos absorben el 75% de las importaciones de éste mercado desde India, el bloque mayor del cual consiste de chutney, para el cual no pueden anticiparse mejoras de consecuencia en las ventas. Sin embargo, importación desde Jamaica de tajadas en salmuera y almíbar han mostrado recientemente aumentos considerables, aunque las cantidades actuales de producto no se difunden por separado en las estadísticas oficiales del comercio. Las importaciones de chutney pueden aumentar levemente, pero las ventas de otros productos (harina y tajadas desecadas) tienen posibilidad de permanecer insignificantes.

The market for mango products with particular reference to the United Kingdom

INTRODUCTION

The principal mango products entering international trade, and with which this report mainly deals, are mango chutneys, pickles, juice, canned mangoes in syrup and slices in brine. Other products of lesser importance also considered are mango nectar, pulp, jam, flour and dried slices. Thus in terms of the variety of product forms in which it is available, the mango is the most versatile of all the minor tropical fruits.

Production

India is by far the most important producer of mango products, and is the source of the bulk of those products traded on the international market.

Other producer countries of importance in world trade are Jamaica and South Africa. Mexico, Haiti, China, Taiwan, Pakistan, Ceylon, Guatemala, Venezuela, Cuba, Dominica, Israel, Australia, Kenya and Tanzania are or have also been producers and small spasmodic exporters.

The United Kingdom, after India, is the second most important producer of mango chutney, which is prepared from mango slices in brine imported mainly from India and Jamaica.

Total world production figures for the various mango products are not available, and even if they were, their reliability as demand trend indicators in the short term would be extremely questionable due to the factors discussed below.

Problems of mango product production

A serious handicap to the establishment of an efficient and stable processing industry for mango products is the erratic nature of the mango crop, for it often happens that a heavy crop is followed by a very light one. This cycle is not invariably biennial, however, and it is by no means unknown for several poor crops to be obtained in consecutive seasons. Thus a guaranteed supply of fresh fruit cannot be assured to the processor.

Another factor affecting the supply of raw material, and which may become of increasing significance in certain countries — eg South Africa — is an expansion in overseas markets for fresh mangoes. Here improved storage techniques are important for they could open the way to sizeable shipments by sea to the United Kingdom and European markets, providing trials with produce from South Africa and certain Caribbean countries are successful. In this way a greater proportion of mango crops produced throughout the world could be exported fresh so reducing supplies available to canneries, particularly as prices of these fresh mangoes could fall on the markets of importing countries thus encouraging the consumer to buy the fresh fruit as opposed to the canned product.

In certain countries the production of mangoes canned in syrup can also be affected by the availability of other fresh fruits. In Jamaica, for example, if pineapples are in plentiful supply canneries tend to switch to them from mangoes as markets for canned pineapples are far more stable and easier to tap than are those for canned mangoes. (1)

International trade: exports

India dominates world trade in mango products. Her total exports of these products amounted to approximately 11,150 tons in 1969/70. This total is almost exactly twenty times the tonnage exported by Jamaica, the world's second supplier, which amounted to 556 tons in 1969. South Africa is the next most important exporter, with world sales of approximately 200 tons. These three countries, namely India, Jamaica and South Africa, almost certainly account for more than 90% of total international trade. Other nations exporting mango products include Mexico, Ceylon, Pakistan, the USA, Guatemala, Venezuela, mainland China, Israel and Cuba. The United Kingdom is an important source of those mango products imported into continental Europe, and indeed is the world's second most substantial producer and exporter of mango chutneys, prepared from brined mango slices, imported from India, Jamaica and Australia.

Statistical information relating to trade in mango products is extremely limited. Indeed of the three major producing countries, India alone shows a reasonably comprehensive breakdown of her exports of individual mango products, though even she does not show all products separately and mangoes in syrup for example are categorised under the general heading of "Fruit preserved in syrup".

Jamaica combines her exports of mangoes in both brine and syrup under a single heading in her trade returns, but does specify mango pulp separately.

South Africa on the other hand, which is the world's third most important exporter of mango products, does not quantify these products separately in her official trade statistics.

It is therefore apparent that the dearth of statistical trade data precludes accurate assessments of trends and quantities of the various mango products traded internationally. Estimates from members of the trade are used, however, to make up for deficiencies in official statistics.

MAJOR EXPORTING COUNTRIES

India

As mentioned above, India is the major source of mango products traded internationally. There follows an analysis of each commodity or commodity group which together make up this trade:

a. Mango juice (including nectar)

Mango juice and mango nectar are virtually the same product — mango pulp diluted with water — but so far as India's products are concerned the juice contains a higher percentage of pulp (about 45%) than the nectar (about 35%).

Mango juice is the most important mango product, by both weight and value, that is exported by India.

Table I shows a breakdown of her exports in this commodity over the past five years. As can be seen from this table, exports increased from 1,357 tons in 1965/66 to 7,620 tons in 1969/70. The USSR provides by far the most important market, accounting for 1,012 tons in 1965/66 and increasing to 6,367 tons in 1969/70; she took 74% by weight and 67% by value of India's total exports over the period. With the signing of trade agreements and rupee payment schemes, the USSR has increased her share of India's export output of mango juice over the five-year period represented in Table I from 75% and 70% by weight and value respectively in 1965/66 to 84% and 77% by the same criteria in 1969/70.

Insofar as the rest of the world is concerned, India's sales of mango juice were 345 tons in 1965/66 and 1,253 tons in 1969/70, the increase having been steady except for 1967/68 when 1,274 tons were exported. Most of this trade is with Persian and Aden Gulf States, Kuwait and Saudi Arabia being the two most important outlets, followed by Qatar and Trucial Oman, Bahrein, South Yemen, Somalia and Muscat. These countries together increased their intake from India over this period from 331 tons to 1,127 tons. Their combined imports were in fact 1,236 tons in 1967/68 but as already noted exports in this year were high and out of line with normal levels. In the later years Kuwait's imports have declined while Saudi Arabia's have increased.

Table I
Mango juice : exports from India

		1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS	M.Tons	1,357	2,010	3,336	2,921	7,620
of which to:-	£'000	148.3	228.6	406.3	410.0	828.5
German Federal Republic	M. Tons	3	-	1	9	28
	£'000	0.5	-	0.1	1.5	4.6
United Kingdom	M. Tons	-	27	11	11	47
	£'000	0.1	5.8	1.8	2.0	8.6
USSR	M. Tons	1,012	1,397	2,062	1,966	6,367
	£'000	104.4	142.1	221.4	259.2	640.7
Yugoslavia	M. Tons	-	54	-	-	2
	£'000	-	7.9	-	-	0.3
Bahrein	M. Tons	2	6	42	78	110
	£'000	0.3	0.7	5.8	11.8	17.2
Kuwait	M. Tons	124	433	955	446	162
	£'000	16.4	59.1	141.7	73.7	25.6
Muscat	M. Tons	4	3	3	23	6
	£'000	0.6	0.3	0.5	5.8	0.9
Qatar and Trucial Oman	M. Tons	7	9	36	97	232
	£'000	1.0	1.3	5.4	13.4	35.1
Saudi Arabia	M. Tons	163	15	180	182	560
	£'000	19.0	2.4	23.3	25.3	77.4
South Yemen (Aden)	M. Tons	24	34	7	38	27
	£'000	3.5	4.8	1.0	6.5	4.2
Somalia	M. Tons	7	17	13	47	30
	£'000	1.0	2.0	1.9	6.8	5.0
Other countries	M. Tons	11	15	26	24	49
	£'000	1.5	2.2	3.4	4.0	8.9

— Nil or negligible

- Notes: 1. 12-monthly periods begin on 1 April of first year shown.
2. Commodity not separately specified before 1965/66.

Source:- Foreign Trade of India
Department of Commercial Intelligence and Statistics

The only West European countries shown separately in India's export statistics are the United Kingdom and the German Federal Republic (hereafter referred to as Germany). Exports to the former averaged 24 tons between 1966/67 and 1969/70, demand depending almost entirely on the requirements of the Pakistani and Indian immigrant population. As regards Germany, imports amounted to a total of only 13 tons between 1965/66 and 1968/69 but rose appreciably in 1969/70 to 28 tons. This substantial increase in volume (though still less than ½% of India's total exports) should not automatically be taken as a demand trend indicator.

b. Mango chutneys and pickles

Mango chutneys (with sugar) and pickles (without sugar) together represent India's second most important exported mango product group.

Table II shows India's exports of this group of products between 1960/61 and 1964/65.

Tables III and IV show exports of the same products between 1965/66 and 1969/70 subdivided respectively into those with and without sugar.

It can be assumed that Tables III and IV together show the same range of products as Table II, as the trend established in the latter is closely maintained by the aggregates of Tables III and IV.

Table II
Mango pickles : exports from India

		1960/61	1961/62	1962/63	1963/64	1964/65
TOTALS	M.Tons	1,039	1,205	1,336	1,293	1,420
of which to:-	£'000	146.7	171.5	188.7	182.2	211.1
Denmark	M.Tons	12	16	11	10	14
	£'000	2.6	3.5	2.5	2.2	3.0
German Federal Republic	M.Tons	3	10	19	23	40
	£'000	0.5	1.9	3.2	3.7	6.5
Netherlands	M.Tons	9	19	17	19	38
	£'000	1.4	3.2	2.3	2.7	5.6
United Kingdom	M.Tons	396	620	874	645	620
	£'000	48.3	76.8	105.1	76.3	81.6
USSR	M.Tons	-	-	-	70	-
	£'000	-	-	-	9.3	-
Hong Kong	M.Tons	8	11	11	12	14
	£'000	1.9	2.6	2.7	3.3	3.8
Iraq	M.Tons	408	303	204	278	359
	£'000	57.6	39.2	29.6	38.1	43.9
Kuwait	M.Tons	10	18	21	25	35
	£'000	1.8	3.2	4.1	5.1	6.8
Malaysia and Singapore	M.Tons	16	18	39	21	27
	£'000	4.1	4.7	10.1	5.8	7.7
Saudi Arabia	M.Tons	21	30	27	21	74
	£'000	1.9	2.9	2.6	2.7	9.5
Canada	M.Tons	14	20	23	17	24
	£'000	3.1	4.4	4.6	3.9	6.0
United States	M.Tons	29	49	52	67	112
	£'000	6.6	12.8	13.8	14.7	23.7
Other countries and unspecified transactions	M.Tons	113	91	38	85	63
	£'000	16.9	16.3	8.1	14.4	13.0

— Nil or negligible

Notes:- 1. 12-monthly periods begin on 1 April of first year shown
2. Commodity not separately specified before 1960/61 and grouped with Mango Chutney after 1964/65.

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Table III
Mango chutney, pickles, etc with sugar : exports from India

		1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS	M.Tons	1,164	1,254	1,103	1,385	1,380
of which to:-	£'000	176.2	171.3	176.0	242.0	235.9
Denmark	M.Tons	26	30	31	36	36
	£'000	4.4	6.7	6.8	8.3	8.0
German Federal Republic	M.Tons	28	44	54	83	96
	£'000	5.3	7.5	11.0	15.7	17.6
Netherlands	M.Tons	23	25	55	64	48
	£'000	3.8	3.5	8.6	10.2	7.7
Sweden	M.Tons	6	4	5	7	10
	£'000	1.8	1.5	1.8	2.7	4.2
United Kingdom	M.Tons	724	894	718	858	883
	£'000	87.7	102.0	92.8	121.8	114.5
Hong Kong	M.Tons	10	5	6	12	20
	£'000	2.6	1.1	1.3	3.6	5.7
Japan	M.Tons	16	8	13	23	19
	£'000	4.5	1.9	2.9	6.2	4.2
Malaysia	M.Tons	25	19	4	10	6
	£'000	7.1	3.0	1.2	3.1	2.0
Singapore	M.Tons	-	25	29	23	23
	£'000	-	5.4	6.8	7.3	7.0
Canada	M.Tons	26	17	26	31	30
	£'000	6.6	4.1	5.9	7.5	10.0
United States	M.Tons	242	151	128	183	156
	£'000	44.7	28.6	28.6	42.4	42.1
Other Countries	M.Tons	38	32	34	55	53
	£'000	7.7	6.0	8.3	13.2	12.9

— Nil or negligible

- Notes:- 1. 12-monthly periods begin on 1 April of first year shown
2. Mango Chutney grouped with other chutneys before 1965/66

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Table IV
Mango chutney, pickles, etc without sugar : exports from India

		1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS	M.Tons	418	454	319	544	588 ✓
of which to:-	£'000	61.0	56.1	37.9	73.1	92.5
United Kingdom	M.Tons	113	133	139	211	235
	£'000	15.3	17.8	17.2	28.7	30.7
Iraq	M.Tons	200	195	93	199	131
	£'000	27.1	18.9	6.1	17.0	18.3
Kuwait	M.Tons	10	32	13	47	120
	£'000	1.8	4.5	2.1	7.5	20.6
Qatar and Trucial Oman	M.Tons	3	5	4	10	13
	£'000	0.9	0.7	1.1	2.2	2.9
Saudi Arabia	M.Tons	53	29	12	16	1
	£'000	6.1	3.1	1.5	3.2	0.2
Canada	M.Tons	5	5	11	8	12
	£'000	1.2	1.1	1.6	2.6	3.3
United States	M.Tons	14	14	16	18	22
	£'000	3.9	2.4	3.4	4.6	6.5
Other countries	M.Tons	20	41	31	35	54
	£'000	4.7	7.6	4.9	7.3	10.0

- Notes:- 1. 12-monthly periods begin on 1 April of first year shown
2. Mango Chutney grouped with other chutneys before 1965/66

Source: *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Indian exports of mango chutneys and pickles have grown steadily over the period 1960/61 to 1969/70, from 1,039 tons to 1,968 tons, which represents an increase of 89%.

As with mango juice, the bulk of these exports go to one country, and in this case it is the United Kingdom. Table V shows developments in total trade for pickles and chutneys in the three main markets – the United Kingdom, the United States and Iraq. These countries together accounted for 80% and 78% of India’s exports in the first and second five year periods of the decade reviewed.

Table V
Average annual exports of mango chutneys and pickles from India to selected countries

		1960/61/1964/65	1965/66/1969/70
TOTAL	M.Tons	1,259	1,722
of which to:			
United Kingdom	M.Tons	631	982
	Percentage	50%	57%
United States	M.Tons	62	189
	Percentage	5%	11%
Iraq	M.Tons	310	164
	Percentage	25%	10%

The United Kingdom’s share of India’s exports has increased from an average of 50% in the first half of the 1960’s to 57% in the second half. Actual average tonnage traded has increased by more than 50% from 631 tons to 982 tons.

Over the same period the United States has rapidly expanded her average share of Indian exports from 5% to 11%, and has more than trebled her average intake from 62 tons to 189 tons.

Iraq however is a declining market, whose average imports have gone down from 310 tons to 164 tons, and whose share has been reduced from 25% to 10%. Indeed, from importing an average of five times as much pickle and chutney as the United States between 1960/61 and 1964/65, she imported on average less than the United States between 1965/66 and 1969/70.

The breakdown of India’s exports, since 1965/66, into product groupings with and without sugar yields some useful information. The shares of the two groupings are summarised below and show that there has been a slight increase in the proportion of sales of products without sugar.

Mango chutneys and pickles					
% of Exports:	1965/66	1966/67	1967/68	1968/69	1969/70
with sugar	74	73	78	72	70
without sugar	26	27	22	28	30
Total	100	100	100	100	100

Chutneys and pickles with sugar

India’s exports of this commodity group have fluctuated year by year but there has been an underlying upward trend. The 1,380 tons exported in 1969/70 represents a rise of 19% over the 1,164 tons exported in 1965/66. The United Kingdom (65%) and the United States (14%) have together accounted for almost 80% of India’s total exports between 1965/66 and 1969/70. Trade with the United Kingdom fluctuated between 718 and 894 tons but the underlying trend has been upwards; exports to

this market in 1969/70 were 883 tons. Exports to the USA have been relatively steady in the last four years, averaging 151 tons; substantially more, 242 tons, was exported in 1965/66 but this quantity was out of line with previous and subsequent levels.

It should also be noted that exports to Germany, the Netherlands and Denmark have been increasing steadily, the only distortion in the pattern being a decline in exports to the Netherlands in 1969/70. These countries together took 77 tons in 1965/66 and 180 tons in 1969/70 (183 tons in 1968/69), with Germany showing the most rapid market growth, from 28 tons to 96 tons. This trade however only represented 1.7% of India's total exports of this product group in 1969/70, so should not be emphasised as being a great significance so far as India herself is concerned, though it suggests an awakened and increasing interest.

Chutneys and pickles without sugar

The United Kingdom and Iraq provide by far the most important markets for this group of commodities, together accounting for 71% of India's exports between 1965/66 and 1969/70. The market in Iraq appears to be in a slow state of decline, although it is difficult to decipher a trend from such an irregular pattern of figures. The United Kingdom's imports however have more than doubled over the period, having increased steadily from 113 tons to 235 tons, compared with an increase in total exports from India from 418 tons to 588 tons, a 41% improvement. Kuwait has also dramatically increased its imports, from 10 tons in 1965/66 to 120 tons in 1969/70, whereas exports to Saudi Arabia have fallen away even more dramatically from 53 tons in 1965/66 to only one ton in 1969/70.

c. Mango slices in brine

Mango slices in brine, which category includes small quantities packed in vinegar, or hard-packed in salt, are used exclusively for the preparation and manufacture of chutneys and pickles.

Table VI shows India's exports of this commodity since 1964/65, before which they were not indicated separately in her official trade returns.

Table VI
Mango slices in brine : exports from India

		1964/65	1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS	M.Tons	455	548	273	149	188	968 ✓
of which to:-	£'000	37.6	46.0	29.3	12.8	21.7	94.0
German Federal Republic	M.Tons	2	-	-	-	-	19
	£'000	0.4	-	-	-	-	3.4
United Kingdom	M.Tons	439	497	165	144	188	925 ✓
	£'000	34.7	37.2	12.3	12.1	21.7	86.6
USSR	M.Tons	10	50	100	-	-	-
	£'000	1.7	8.5	15.6	-	-	-
Other countries	M.Tons	4	1	8	5	-	(a) 24
	£'000	0.8	0.3	1.4	0.7	-	4.0

— Nil or negligible

(a) Included 15 M.Tons to Somalia

Notes:- 1. 12-monthly periods begin on 1 April of first year shown
2. Commodity not separately specified before 1964/65

Source:- Foreign Trade of India
Department of Commercial Intelligence and Statistics

India's exports of this product have fluctuated violently over the period shown, from 149 tons in 1967/68 to 968 tons in 1969/70, and no discernable trend is apparent. Only certain varieties of mango are suitable for brining, and it is likely that the availability of these varieties is the main factor affecting production. In any event demand would appear not to be the determining influence over supplies as importers in the United Kingdom, by far the most important market, state that they have frequently been undersupplied in recent years. The United Kingdom market absorbed 91% of India's exports of brined mangoes between 1964/65 and 1969/70, her imports ranging from 144 tons to 925 tons.

Only the USSR and Germany are shown separately in Table VI as other importing countries. The former's imports increased from 10 to 100 tons over the first three years but none has been imported since; it is concluded that the earlier trade was probably part of a bilateral trade agreement; exports to Germany are shown in the first and last years; as with juice this may have been related to commercial agreements. In all events neither the USSR nor Germany is an established market.

d. Mangoes preserved in syrup

There is no separate category in India's official trade returns for mangoes preserved in syrup, but only a composite category entitled "Fruit Preserved in Syrup". It is estimated that between 80% and 90% of exports of this commodity group sold in Europe consists of mangoes preserved in syrup.

Table VII shows India's exports between 1965/66 and 1969/70. The United Kingdom is India's most important customer for this commodity, accounting for 63% of the latter country's exports during the five years shown in Table VII. Indeed she has more than doubled her imports over the period from 62 tons in 1965/66 to 131 tons in 1969/70, and the trend appears to be one of an average increase of 20% per annum.

Table VII
Fruit preserved in syrup : exports from India

		1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS	M.Tons	88.6	130.9	148.5	189.0	292.4
of which to:-	£'000	18.8	25.0	28.0	38.1	55.2
United Kingdom	M.Tons	62.3	91.5	113.9	134.6	130.7
	£'000	13.6	18.0	20.7	27.1	27.4
German Federal Republic	M.Tons	8.3	15.1	2.8	8.6	23.8
	£'000	1.4	2.2	0.7	1.6	4.7
USSR	M.Tons	-	-	-	-	15.4
	£'000	-	-	-	-	2.2
Yugoslavia	M.Tons	-	-	-	-	84.2
	£'000	-	-	-	-	12.0
Kuwait	M.Tons	1.7	1.3	2.8	17.3	11.2
	£'000	0.4	0.4	0.7	3.0	2.5
Netherlands	M.Tons	1.3	4.7	2.8	0.8	-
	£'000	0.2	0.8	0.4	0.2	-
Other countries	M.Tons	15.0	18.3	26.2	27.7	27.1
	£'000	3.2	3.6	5.5	6.2	6.4

— Nil or negligible

- Notes:-**
1. 12 monthly periods begin on 1 April of first year shown
 2. Commodity not separately specified before 1965/66.

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Exports to both Germany and Kuwait have been erratic and no firm trends have been established, although the underlying direction appears to be upwards. Yugoslavia and the USSR were important new customers in 1969/70, buying 84.2 tons and 15.4 tons respectively, assumed to be under new trade agreements; whether they will follow this up with fresh orders in years to come remains to be seen. It has been known for new products to establish themselves on the market of an importing country after they have been imported under a trade agreement. On the other hand, as with mangoes in brine, also assumed to be sold to the USSR under such an agreement, sales have built up rapidly over a few years, only to be brought to an abrupt halt. Yugoslavia's imports in 1969/70 of a product, or products, previously unknown suggests it is unlikely that this level of trade will be sustained except as a result of an extended bilateral trade agreement.

e. Dried mango slices

TABLE VIII shows India's exports of dried mango slices from 1965/66 to 1969/70. This product was not specified separately before 1965/66.

Table VIII
Mango slices dried : exports from India

		1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS	M.Tons	14.5	47.6	15.6	4.4	25.1
of which to:-	£'000	1.9	3.9	1.7	1.1	3.6
United Kingdom	M.Tons	10.2	45.6	6.4	1.1	21.2
	£'000	1.4	3.7	1.1	0.4	2.6
Hong Kong	M.Tons	0.1	1.3	6.4	-	-
	£'000	-	0.1	0.4	-	-
Qatar	M.Tons	-	-	-	1.6	0.8
	£'000	--	-	-	0.3	0.2
South Yemen (Aden)	M.Tons	3.1	-	-	-	-
	£'000	0.4	-	-	-	-
United States	M.Tons	-	0.1	0.1	0.3	1.4
	£'000	-	-	-	0.2	0.4
Other Countries	M.Tons	1.1	0.6	2.7	1.4	1.7
	£'000	0.1	0.1	0.2	0.2	0.4

— Nil or negligible

- Notes:- 1. 12-monthly periods begin on 1 April of first year shown.
2. Commodity not separately specified before 1965/66.

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

The United Kingdom accounts for almost 80% of India's exports of dried mango slices, and indeed is the only country to have bought supplies in each year shown on the table. This trade however has fluctuated violently between 1.1 tons in 1968/69 and 45.6 tons in 1966/67, averaging out at 17 tons per annum.

Other customers with intermittent requirements include Hong Kong, Qatar, South Yemen and the United States.

It is unlikely that trade in this product will increase to any great extent over the next few years, as the product is virtually unknown outside the countries of production and moreover there are extensive problems of dehydration concerning shape, texture, colour and flavour. (2)

f. *Mango flour*

India's exports of mango flour are shown in Table IX. It was not quantified as a product on its own in the official Indian trade statistics before 1967/68.

Table IX
Mango flour : exports from India

		1967/68	1968/69	1969/70
TOTALS	M.Tons	2.5	4.1	2.5
of which to:-	£'000	0.5	1.0	0.7
United Kingdom	M.Tons	1.6	2.1	1.4
	£'000	0.3	0.4	0.3
Kuwait	M.Tons	-	0.2	0.2
	£'000	-	-	0.1
Nigeria	M.Tons	0.1	0.2	0.1
	£'000	-	0.1	-
Canada	M.Tons	0.3	0.8	0.7
	£'000	0.1	0.3	0.3
United States	M.Tons	0.1	0.5	0.1
	£'000	0.1	0.2	-
Other countries	M.Tons	0.4	0.3	-
	£'000	-	-	-

— Nil or negligible

Notes:- 1. 12-monthly periods begin on 1 April of first year shown.
2. Commodity not separately specified before 1967/68.

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics.

As can be seen from Table IX, India's trade in this product is minimal, averaging only 3 tons per annum over the period shown. The United Kingdom accounts for most of these exports with an average of 1.7 tons per annum. Canada has imported a total of 1.8 tons over the three years shown, other minor outlets include the United States, Nigeria and Kuwait.

g. *Mango jams, pulps and pastes etc.*

Exports of these products are shown in Table X. They were not separately specified before 1965/66.

Indian exports of these products fluctuated between 51 and 375 tons per annum but, if exports to the USSR are eliminated, have shown a consistent upward trend from 46 to 275 tons.

The UK is now the most important market, her imports having been 139 tons in 1969/70; this compares with 3 tons only in 1965/66. It is thought exports to the UK are comprised almost wholly of pulp since members of the trade in the UK estimated the demand for this commodity in 1970 was in excess of 10,000 cases (130+ tons). It is thought that a little jam may be included though most importers in the UK do not deal in it. The trade in the UK believes that the market for mango pulp is at or is approaching saturation point.

Table X
Mango jams, jellies, purees, pulps and pastes : exports from India

		1965/66	1966/67	1967/68	1968/69	1969/70
TOTALS of which to:-	M.Tons £'000	164 24.9	51 8.6	79 14.9	100 18.9	375 56.0
United Kingdom	M.Tons £'000	3 0.7	10 1.9	39 7.1	39 7.8	139 23.5
USSR	M.Tons £'000	118 19.7	- -	- -	- -	100 10.2
Kuwait	M.Tons £'000	18 0.9	4 0.5	20 3.6	7 1.5	3 0.6
Qatar and Trucial Oman	M.Tons £'000	- -	2 0.3	- 0.1	20 2.6	2 0.4
Saudi Arabia	M.Tons £'000	13 1.6	6 1.0	11 1.8	21 3.7	80 11.8
South Yemen (Aden)	M.Tons £'000	4 0.8	26 4.2	3 0.7	- -	32 5.9
Other countries	M.Tons £'000	8 1.2	3 0.7	6 1.6	13 3.3	19 3.6

— Nil or negligible

- Notes:- 1. Commodity not separately specified before 1965/66
2. 12-monthly periods begin on 1 April of first year shown

Source: *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Persian and Aden Gulf countries (Kuwait, Saudi Arabia, South Yemen, Qatar and Trucial Oman) together account for a further significant share of India's exports, amounting to 117 tons in 1969/70. Expansion to this total from 35 tons in 1965/66 has been fairly steady and regular and should continue in the immediate future; however which of the products is most important is not known. The USSR bought 118 tons from India in 1965/66 and 100 tons in 1969/70, with no trade at all between the two countries in the intervening years. Such a trade pattern makes it impossible to predict future prospects.

These products are almost completely unknown in other European markets, the only statistic available being that of German imports of 100 kilograms of mango jam in 1967 (3).

Jamaica

Jamaica is the world's second most important exporter of mango products. The bulk of these exports has until recently consisted of mango slices in brine. Canned mangoes in syrup are now of increasing importance, and there is a very small overseas trade in Jamaican mango nectar. Up to 1967 Jamaica also sold small quantities of mango pulp abroad, but no exports of this commodity have appeared in the official trade returns in the two latest years for which statistics are available — 1968 and 1969.

a. *Mangoes in brine or syrup, whole or sliced*

Table XI shows a breakdown of Jamaica's exports of these products by weight and value, averaged per annum over the periods 1957–59 and 1960–62, and yearly between 1963 and 1969.

Table XI
Mangoes in brine or syrup, whole or sliced : exports from Jamaica

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968	1969
TOTAL	M.Tons	299.8	621.1	419.8	420.0	532.9	364.6	514.6	304.2	556
of which to:-	£'000	24.8	33.3	22.0	32.0	33.6	30.3	57.2	28.5	64.7
United Kingdom	M.Tons	237.1	563.4	343.8	328.8	436.2	282.6	415.3	197.0	310
	£'000	18.8	28.7	16.1	24.8	25.1	22.3	47.4	17.0	30.8
United States	M.Tons	62.7	56.5	71.3	89.7	93.6	79.2	94.5	101.2	232
	£'000	6.0	4.4	5.4	6.9	8.0	7.5	8.9	10.5	30.7
Other countries	M.Tons	-	1.2	4.7	1.5	3.1	2.8	4.8	6.0	14
	£'000	-	0.2	0.5	0.3	0.5	0.5	0.9	1.0	3.2

— Nil or negligible

Source:- *External Trade of Jamaica*
Department of Statistics

From the data in Table XI it can be seen that no overall upward or downward trend is apparent in Jamaica's total exports. Since 1964 sales have fluctuated considerably, between 304 tons in 1968 and 556 tons in 1969. It can be assumed that this is largely due to the erratic nature of the mango crop, as information from the trade indicates that demand for slices in brine is steady in the United Kingdom, Jamaica's biggest market, and that whatever is offered is readily absorbed. (The low level of exports in 1968 was due to drought conditions.)

The United Kingdom is Jamaica's most important customer, taking an annual average of 74% of the latter's exports between 1963 and 1969, actual quantities varying between 197 tons in 1968 and 436 tons in 1965. The United States provides Jamaica with her only other major outlet, and in 1969 she took 42%, 232 tons, of Jamaica's exports compared with only 17%, 71 tons, in 1963. The United Kingdom's share has fallen substantially over the same period from 82%, 344 tons, in 1963 to 56%, 310 tons, in 1969. In order to get a picture of the breakdown of this trade into mangoes canned in syrup and mango slices in brine an analysis of individual markets is required.

Trade sources in the United Kingdom indicated sales of about 130 tons of mangoes in syrup and 200 tons of mango slices in brine in 1970. This total figure of 330 tons correlates closely with the official trade statistic of 310 tons in 1969.

Jamaican mangoes in syrup are of the 'Black' variety, are canned whole, and appeal exclusively to the West Indian immigrant sector of the market. This community expanded rapidly in the 1960's until 1967 when legislation curtailed quite drastically the number of new entrants and therefore the number of new potential consumers.

In so far as Jamaica's exports to the United States are concerned, with the exception of the 79 tons sold in 1966, trade expanded slowly until 1968 and then more than doubled in 1969. There is no indication as to the proportions of this trade consisting of brined mango slices, or canned mangoes in syrup. The only relevant figure available is that 90.7 tons of fresh and canned mangoes were imported by the United States from Jamaica in 1967. (see Table XXI on page 61). Assuming the bulk of this trade was in fresh mangoes, and remembering that total imports of brined and canned mangoes together stood at 94.5 tons in 1967, it follows that most of this latter figure consisted of mango slices in brine.

b. *Mango pulp*

Table XII shows Jamaica's exports of mango pulp. This trade is now defunct. The maximum tonnage exported in any one year was 17.4 tons in 1966, 14.1 tons of which went to Canada. Other importing countries were the United States, Barbados, the Bahamas and the United Kingdom, but Canada alone made regular annual purchases. This product was not a success on the United Kingdom market as it was considered not sweet enough by the Indian and Pakistani communities, the only consumers.

Table XII
Mango pulp : exports from Jamaica

		1957-59 Average	1960-62 Average	1963	1964	1965	1966	1967	1968	1969
TOTAL	M.Tons	4.1	1.8	5.3	2.8	1.9	17.4	0.8	-	-
of which to:-	£'000	1.7	0.2	0.5	0.4	0.2	1.1	0.1	-	-
United Kingdom										
	M.Tons	4.0	0.4	-	0.3	-	-	-	-	-
	£'000	1.7	-	-	0.1	-	-	-	-	-
Bahamas										
	M.Tons	-	-	-	-	0.3	-	-	-	-
	£'000	-	-	-	-	-	-	-	-	-
Barbados										
	M.Tons	-	-	-	-	-	3.3	-	-	-
	£'000	-	-	-	-	-	0.2	-	-	-
Canada										
	M.Tons	0.1	0.1	0.3	0.2	1.6	14.1	0.8	-	-
	£'000	-	-	-	-	0.2	0.9	0.1	-	-
United States										
	M.Tons	-	1.3	5.0	2.3	-	-	-	-	-
	£'000	-	0.2	0.5	0.3	-	-	-	-	-

— Nil or negligible

Source:- *External Trade of Jamaica*
Department of Statistics

South Africa

There are no official trade statistics published by South Africa relating specifically to the export of any mango product. It has been estimated that the total value of fresh mangoes sold in South Africa probably exceeds R900,000 (£510,000) annually (4).

In 1967/68 the value of fresh mangoes sold internally was about R650,000 (£370,000) representing 8,000 tons of fruit. This means that the total value of those mangoes sold for canning, chutney manufacture or to be exported fresh or processed, was some R250,000 (£140,000) in 1967/68.

The bulk of this latter group is canned in syrup and sold primarily on the home market. Trade sources in the United Kingdom estimate that approximately 15,000 cases of South African canned mangoes in syrup were sold on this market in 1969/70; this represents about 163 tons.

South African canned mangoes are not sweet enough, or of sufficiently good quality as regards fibre content and flavour, to satisfy the "Indian"* sector of the United Kingdom market and they are sold mainly to the "British"* sector, where their more

*For a description of the United Kingdom market sectors, see p.33.

acid flavour is preferred to the Indian product, which is considered by many to be too sweet. South African producers tried to simulate the 'Black' variety of mango from Jamaica, but with little success. In 1968 mango pulp was test marketed, but failed as the only consumers in the United Kingdom, namely people of Indian or Pakistani origins, considered the product neither sweet enough nor of an acceptable flavour. In addition to their being unable to simulate effectively the products of other countries, some members of the trade maintain that South African sales suffer from the fact that some new Commonwealth immigrants in the United Kingdom object to buying goods from this source, besides in any case having a strong loyalty to products from their own countries of origin.

It has been reported that the quality of South African canned mangoes is improving, and the replanting of some citrus areas with mangoes could provide canners with better varieties, enabling them to improve their product still further, and extend the canning season.

OTHER EXPORTING COUNTRIES

International trade in mango products is dominated by the three countries discussed above, namely India, Jamaica and South Africa. These countries apart, there is an almost total lack of officially published trade statistics devoted to mango products.

It is known that Mexico, Haiti and Taiwan are, together with Jamaica, the principal suppliers of canned mangoes in syrup to the United States (5).

Guatemala and Venezuela both supplied mango pulp and paste to the United States in 1967, 34.7 tons and 36.6 tons respectively, (see Table XXI) but details of this trade in other years and to other overseas markets are unknown.

Very small quantities of mango products are also imported into the United Kingdom from Pakistan, Mexico, China and Ceylon, as are mango slices in brine from Australia. This latter trade could develop quite considerably, however, as a major British chutney manufacturing company has established its own mango orchards and brining plant in Australia.

Kenya and Tanzania both exported canned mangoes to the United Kingdom in the past, but these products are now believed to be unavailable.

Israel produces small quantities of canned mangoes, and could decide to step up her production of this product for the export market though she is likely to aim for the more remunerative fresh fruit export market so long as her supplies are limited.

In addition to the trade in mango products produced in mango growing countries there is also the export trade in mango chutney, manufactured from imported raw material, from the United Kingdom to consider. The United Kingdom is the world's second most important exporter of this product, her markets being largely member countries of the European Economic Community.

Athisayam (6) reported for example that the United Kingdom exported or re-exported between 120 and 130 tons of chutney to Germany in 1968. He commented further that a considerable proportion of this product was destined to be consumed by the British Army of the Rhine. The Netherlands and Denmark also import limited quantities. The United Kingdom intermittently re-exports very small quantities of mango juice and slices in syrup, obtained from India and South Africa, to Germany, France, the Netherlands and Denmark, but trade in these products is extremely limited.

International trade: imports

Almost all known exports of mango products are absorbed by five principal national or multi-national markets, namely:

- United Kingdom
- USSR
- Middle East
- EEC and Scandinavia
- North America

The United Kingdom and Middle Eastern markets are the oldest established, and import the widest variety of products. The North American, EEC and Scandinavian markets, on the other hand, are relatively new. They are also of lesser importance at present, in terms of tonnage traded, but are nevertheless expanding more rapidly than the older markets in terms of direct imports from producing countries.

The market in the USSR is more difficult to analyse and predict than those others mentioned above. This is because trade agreements and currency payment schemes are the dominant factors, rather than the interplay of demand and supply. This does not alter the fact that in 1969/70 the USSR was by far the world's most important importer of mango products, accounting for 58% by weight of the exports of India, which is itself the dominant producing country.

There follows an analysis of each of the world's five main markets.

UNITED KINGDOM

Up to 1967/68 the United Kingdom was the principal world market for exported mango products due both to its substantial immigrant population and to the existence of a sizeable section of its community which has worked or lived overseas and has become familiar with these products.

In order to analyse the consumption profile, this market can usefully be divided into three sectors:-

1. Those of Indian or Pakistani descent.
2. Those of West Indian descent.
3. Those of "British" descent.

These three sectors will henceforward be referred to as the "Indian" market, the "West Indian" market, and the "British" market respectively.

Generally speaking, and with the exception of mango slices in brine and some imported sweetened chutneys, products from India are consumed by the "Indian" market, those from Jamaica by the "West Indian" market and those from South Africa by the "British" market.

Mango slices in brine are used in the preparation of various mango chutneys, most of which are consumed by the "British" market, as are some imported ready-made sweet chutneys.

India is by far the most important supplier of mango products to the United Kingdom, and Table XIII shows a breakdown of her exports to this market between 1965/66 and 1969/70. Also shown are percentage figures of total Indian exports that this trade represents.

Table XIII
United Kingdom imports from India : mango products

	1965/66	1966/67	1967/68	1968/69	1969/70
Mango juice					
M. Tons	-	27	11	11	47
% of India's Exports	-	1%	-	-	-
Mango chutney, pickles with sugar					
M. Tons	724	894	718	858	883
% of India's Exports	62%	71%	65%	62%	64%
Mango chutney, pickles without sugar					
M. Tons	113	133	139	211	235
% of India's Exports	27%	29%	44%	39%	40%
Mango slices in brine					
M. Tons	497	165	144	188	925
% of India's Exports	91%	60%	97%	100%	96%
Fruit preserved in syrup					
M. Tons	62	92	114	135	131
% of India's Exports	70%	70%	77%	71%	45%
Mango slices, dried					
M. Tons	10.2	45.6	6.4	1.1	21.2
% of India's Exports	70%	96%	41%	25%	85%
Mango flour					
M. Tons	-	-	1.6	2.1	1.4
% of India's Exports	-	-	64%	51%	56%
Mango jams, pulps, pastes, purees, etc					
M. Tons	3	10	39	39	139
% of India's Exports	2%	20%	49%	39%	37%
Tons TOTAL	1,409.2	1,366.6	1,173.0	1,445.2	2,382.6

- Nil or Negligible

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

The United Kingdom's second source of supply is Jamaica, and Table XIV shows her imports from that country between 1964 and 1969. The percentage of Jamaica's trade in mango products represented by exports to the United Kingdom is also shown. Each product is discussed individually below:

Table XIV
United Kingdom imports from Jamaica : mango products

	1964	1965	1966	1967	1968	1969
Mangoes in brine or syrup, whole or sliced						
M. Tons	328.8	436.2	282.6	415.3	197.0	310.0
% of Jamaica's Exports	78%	82%	78%	81%	65%	56%
Mango pulp						
M. Tons	0.3	-	-	-	-	-
% of Jamaica's Exports	11%	-	-	-	-	-
Tons TOTAL	329.1	436.2	282.6	415.3	197.0	310.0

- Nil or negligible

Source:- *External Trade Bulletin*
Department of Statistics

Mango juice (including mango nectar)

This product is of very limited importance on the United Kingdom market. India is the major supplier, but very small quantities of nectars only are also imported from Jamaica, the United States and Mexico. The Indian product is sold almost exclusively to the “Indian” market, and annual sales amount to an average of rather less than 5,000 cases of 6oz or 12oz cans. At retail level, American and Mexican nectars are very expensive, being four times dearer weight for weight than citrus and tomato juices, and one and a half times dearer than peach or apricot nectars. They are only to be found in exclusive department stores and delicatessens, whereas the Indian product is more widely available.

Prices

Retail prices of nectars in a department store in 1970 were as follows:

<i>Country of Origin</i>	<i>Price</i>	<i>Can size</i>
United States	22½p	12oz
Mexico	25p	12oz

Prospects

Although per capita consumption of fruit juices is rising rapidly in the United Kingdom, it seems unlikely that this trend will be reflected in the demand for mango juice and nectar. There are three main reasons for this. Firstly, sales saturation point has probably been reached within the “Indian” market, the product’s only sizeable outlet. Secondly, mango juice is almost completely unknown to the “British” consumer, and in order to precipitate any substantial upturn in sales, extensive and expensive promotional activity would be required, which relative to the size of the market would not be justified. Thirdly, as was pointed out above, mango juice is too expensive a product in comparison with other fruit juices, and at present price levels remains very much a speciality item, out of reach of the mass market. Demand, which averaged 19 tons per annum between 1965/66 and 1969/70, is likely to remain static.

Mango chutneys and pickles

Chutneys (referred to as “pickles with sugar” in the trade statistics) are preserved with sugar, whereas pickles do not contain any added sweetener and are usually highly spiced and hot to the taste. Almost four times more chutney (883 tons) was imported into the United Kingdom in 1969/70 than pickle (235 tons). Pickles are sold almost entirely through Indian foodstores and restaurants and thus primarily to the “Indian” market. Outlets for chutney, however, can be broadly divided into two categories.

- a. Specialised and good quality chutneys, which are imported either ready bottled, or are bottled here and sold through the retail trade or to Indian restaurants.
- b. Poorer quality chutneys, which are used in the preparation of various composite “sweet pickles” and fruit sauces.

The former category is consumed largely within the “Indian” market, the latter within the “British” market.

As discussed earlier, quite considerable quantities of chutney and very small amounts of pickle are exported and/or re-exported from the United Kingdom to various other West European markets.

India supplies almost all the mango chutneys and pickles imported into the United Kingdom, but very small quantities of specialised items also come from Ceylon and Pakistan.

Trade requirements are that chutneys should be of a light honey colour and not too sweet. Chutney is mainly imported in bulk – 50kg casks – and re-bottled into 10 oz jars for retail sale, or resold in bulk to processors.

Pickles are imported both in bulk – 130 lb casks – for re-bottling, and ready packed in 12 oz retail jars.

Prices

The following prices were quoted in October 1971 for imported Indian products:

Chutneys	50kg cask	£7 cif
Pickles	per lb in bulk	£0.05 cif
Pickles	12 oz jar	£0.17½ cif

Prospects

Imports of pickles have been increasing annually from 113 tons in 1965/66 to 235 tons in 1969/70. This is largely due to an increase in the number of immigrants entering the United Kingdom from India, Ceylon, Pakistan and East Africa over the same period and to the proliferation of Indian restaurants. It is unlikely that the rate of increase established over the last five years will be maintained owing to the restrictions placed upon the number of new immigrants by recently introduced legislation. However, more “British” consumers have become familiar with these pickles as the habit of eating out in Indian restaurants has spread. Indeed future prospects probably depend to a great extent on the “British” sector; in this context it must be said that it is unlikely that pickles will be used extensively in the home, but only as an accompaniment to meals taken when dining out.

Supplies of chutney fluctuated year by year from 1965/66 to 1969/70 though the consistent higher level of imports in the last two years suggest there may be an underlying upward trend. The cheaper chutneys are used, as noted earlier, in the manufacture of various “sweet pickles” and fruit sauces; these products are in constant demand on the UK market, but are such a traditional constituent of the British diet than any sudden or substantial increase in usage is highly unlikely. As regards the better quality chutneys, they have a wide distribution – at retail level to “British” consumers as well as the other ethnic groups and to many caterers including both Chinese and Indian restaurateurs – so the growth potential has probably not been fully realised.

Mango slices in brine

This commodity, which is imported from India, Jamaica and Australia, is used exclusively in the preparation of mango chutney.

Included in imports from India are some 5% of slices packed in vinegar, and some 15% to 20% hard-packed in salt.

Demand in the United Kingdom is estimated at between 800 and 900 tons per annum and there was a considerable annual shortfall in supplies in the years 1966 to 1968.

India is the principal supplier and, as can be seen from Table XIII, imports from this source have fluctuated violently between 144 tons in 1967/68 and 925 tons in 1969/70. Jamaican exports of brined slices are not shown as a separate category in her trade returns, but until very recently most of the category “Mangoes in brine or syrup, whole or sliced” shown in Table XI that were imported into the United Kingdom consisted of this commodity.

The decline in imports from these two countries during 1966-69 was largely attributable to drought conditions, notably in 1968/69. Small quantities of brined

slices are also imported from Australia, where one major British chutney manufacturer grows and processes its own fruit.

Brined slices, which are prepared from fresh unripe but fully developed fruit, which ideally should be low in both fibre and terpene content, are packed after processing into 500 lb casks for export.

For the United Kingdom market, mango slices in brine must have a good texture, be free from coarse or fibrous tissue, and the fruit should be firm and not have a tendency to form a pulp when processed. Colour is also important, a very pale yellow being preferred, and the brine solution should not have been too concentrated leaving the slices over-salty.

Manufacturers tend to buy in stocks whenever brined slices are available as supplies are often erratic due to season by season variations in the mango crop. The product is also considered to benefit from any maturation time it receives in store.

As regards overall quality, importers' and users' opinions vary. The latter have their own specific requirements and will judge new products against these. One manufacturer has stated that in one respect Jamaican slices are superior to Indian — ie they are firmer. In practice a new supplier would have to submit samples for assessment.

Prices

Indian mango slices in brine are currently fetching in the region of £33 per 500 lb 40 gallon cask ex quay or between £150-160 per ton.

Prospects

Important factors to be considered here are intrinsic quality, consistency of product and regularity of supply. If these demands can be met, together with a competitive price, any new product would be favourably considered by the major United Kingdom importers and chutney manufacturers. It has been the case, as stated earlier, that supplies have been hard to obtain in the past, though it is true that they have been easier for the past two seasons. Demand for brined slices is steady, but a major food manufacturer has recently launched a new mango chutney on to the market. This company's needs are modest at present, but should increase as the product becomes better known.

There are two reasons why the production of brined slices, rather than ready-made chutneys, may be the better proposition for export to the UK. Firstly, chutneys made in the United Kingdom from imported brined slices have a flavour which is particularly well suited to the average British palate, being blander than the imported chutneys, and it is the "British" sector of the United Kingdom market which has the widest potential for the expansion of sales, as the "Indian" market is largely saturated and of limited size. Secondly, imported ready-made mango chutneys contain sugar, and are thus subject to a sugar surcharge which applies to all products containing sugar. This has the effect of raising the price of imported chutneys as against those manufactured in this country.

The general consensus of opinion in the trade is that demand for mango slices in brine will expand slowly, but steadily. Exporters able to supply the required quality of product consistently should be able to penetrate the market, though it should be noted that many possible sources of supply have been investigated in the past but have failed to meet the UK processors' requirements, and in this context intrinsic quality has figured quite importantly.

Mangoes preserved in syrup

India, South Africa and Jamaica are the three principal suppliers of this product. Canned mangoes from India are generally considered to be the best, being well

flavoured and non-fibrous in texture. They are packed in a heavy syrup, either as halves or slices. The Alphonse variety of mango is the choicest fruit, although the brand leader "Kissan" is not in fact of this variety. The Indian product is more expensive than those from South Africa and Jamaica, and is sold mainly to the "Indian" market, but is also favoured by "British" gourmets.

The South African product is packed in a much lighter syrup, generally has less flavour and a higher fibre content than that emanating from India, and sells almost exclusively to the "British" market.

Jamaican canned mangoes are usually of the 'Black' variety, though this does not refer to the actual colour of the fruit. They are small mangoes, and are packed whole with the seed still intact. They sell exclusively to the West Indian community, and are generally cheaper than both the Indian and South African products. In recent years sales of Jamaican produced mangoes have increased dramatically largely due to the fact that a British importing company has established its own cannery in Jamaica. Immigration from the West Indies has also been substantial recently, until restricted by legislation, thus boosting the market and the demand for the Jamaican product. This demand, however, is likely to become rather less elastic quite soon as saturation point is approached and immigration decreases. The United Kingdom market is also supplied by very small quantities of an expensive and high quality product from Mexico.

Mainland China also exports canned mangoes to the United Kingdom, but quantities are limited, and the product, which is sold largely to Chinese restaurants, is generally not well liked.

Estimates from the trade of imports entering the United Kingdom from the four main supplying countries in 1969/70 were as follows:

<i>Country of Origin</i>	<i>Quantity</i>
India	12, – 15,000 cases (24 x 18 oz) or 147 to 184 tons
South Africa	15,000 cases (24 x 1 tall) or 163 tons
Jamaica	10,000 cases (24 x 19 oz) or 129 tons
China	2, – 3,000 cases (24 x A2) or 27 to 40 tons

None of the above countries specify exports of canned mangoes separately in their trade returns. Table VII shows India's exports of "Fruit Preserved in Syrup", of which 80-90% consists of canned mangoes in so far as European markets are concerned. Table XI shows Jamaica's exports of mangoes canned in syrup and sliced in brine combined, each commodity representing approximately half the total in 1969.

Prices

Retail prices observed in the last quarter of 1971 were:-

<i>Country of Origin</i>	<i>Brand</i>	<i>Can Size</i>	<i>Price</i>
South Africa	Epicure	16 oz	14½p
India	Madhu	30 oz	40p
India	Kissan	10 oz	16p
Jamaica	White Bunny	16 oz	14½p

"Kissan" is the leading brand of canned mangoes from India on the United Kingdom market, and has established a good reputation for quality within the "Indian" market. "Madhu" is the major brand of Alphonse mangoes.

Prospects

Mangoes are an expensive fruit, the dearest being those from India. Yet sales of Indian mangoes have been increasing more rapidly than those from South Africa. The former appeal not only to the "Indian" market, but also to the top end of the "British" market. Immigration from India and Pakistan, and also of Indians and

Pakistanis from East Africa has been at a high level until recently and this has helped to boost sales. Owing to the restrictions on immigration now in force demand from the "Indian" sector will grow less rapidly in future and any further substantial rise in sales will depend chiefly on the "British" public acquiring a taste for mangoes. Indeed, the major Indian exporter is at present attempting to produce a canned mango product which will appeal to the "British" and European palate more than the very sweet varieties favoured by the "Indian" consumer, but this is necessarily a long-term project.

Sales in recent years have increased quite rapidly to a level of 500 tons (approximately) in 1969/70. By 1973/74, a considerable increase in the current mango area of around 2 million acres is expected (7), and, since South Africa is also expanding production, it may soon be possible to promote sales of both fresh and canned mangoes on a much wider front, given the implication of a certain corresponding decline in price levels. With the development of new storage and carriage techniques, however, the canned product will face increased competition from fresh fruit, and indeed this pressure is already beginning to be felt according to the trade, especially by canned mangoes from the West Indies. In the long run, though, greater acceptance of, and market penetration by, the mango in any form can only have a beneficial effect on the prospects for the canned product.

Dried mango slices

India is believed to be the sole supplier of this product. There are two types – "Omsat" which is eaten as a sweetmeat and "Amchoor" which is used in the preparation of curries as a substitute for tamarind. Dried slices are imported in sacks, and repacked into cellophane containers of between 4 oz and 1 lb in weight. They are retailed through Indian and Pakistani foodstores.

Prices

Import price:	20p per lb cif
Retail: Amchoor	10p per 4 oz packet

Prospects

Although demand for this product is described as 'buoyant' by one importer, quantities traded are very small, averaging only 15 tons per annum between 1965/66 and 1969/70. Imports have fluctuated violently between 1.1 tons in 1968/69 and 45.6 tons in 1966/67 owing to supply shortages on account of poor crops and drought.

Demand is not expected to show any significant improvement.

Mango flour

This product is of very minor importance on the United Kingdom market, imports averaging less than 2 tons per annum, all from India.

Mango jam

No importers of this product can be traced at present, therefore sales are presumed to be negligible.

Mango pulp

Mango pulp makes up the bulk of those commodities imported from India and shown in Table XIII under the sub-heading "Mango jams, pulps, pastes, purees, etc".

This product used to be imported from Jamaica (see Table XII) and Tanzania. A South African cannery made a trial shipment in 1968 but the product did not sell because the "Indian" consumers, who are the pulp's only purchasers, preferred the stronger flavoured and sweeter Indian pack.

Pulp can be made from several varieties of mango, to which sugar is added, and it is particularly popular amongst East African Indians who use it in the preparation of desserts and soft drinks. It is also eaten as an accompaniment to curry.

It is used by at least one small specialised ice-cream manufacturer, but only in very limited quantities. Major food manufacturers have rejected mango as a flavour for ice-creams or soft drinks on the grounds that such products would not be sufficiently acceptable to their customers, and that the costs incurred in obtaining a true and lasting mango flavour from a fresh fruit product would be prohibitive. (There is at least one synthetic mango flavour available on the United Kingdom market.)

Prices

Both "Madhu" and "Kissan" brands of mango pulp, packed in 30 oz cans, were found to be on sale in retail Indian foodstores in late 1971 at between 37½p and 41p.

Prospects

Imports of the product group which largely consists of mango pulp have increased steadily from 3 tons in 1965/66 to 139 tons in 1969/70, with a short hiatus in 1968/69 when they remained steady at 39 tons. The growth in the market is due to a rapid build up of the "Indian" market due to immigration. However, further improvement of sales will be harder to achieve since restrictions on immigration are now in force.

USSR

The USSR is at present the world's most substantial importer of mango products, importing these from India under various trade agreements and rupee payment schemes. As can be seen from Table XV the bulk of this trade is in mango juice, imports of which stood at a massive 6,367 tons in 1969/70. Trade in this commodity alone in that year amounted to more than twice the United Kingdom's total imports by weight of all mango products from all sources. It cannot be assumed however that this trade will continue in such quantities, as trade agreements tend to be inflexible by nature. The USSR's imports of brined mangoes illustrates this point: 10 tons were imported from India in 1964/65, 50 tons in 1965/66 and 100 tons in 1966/67, since which time there has been absolutely no trade whatsoever between the two countries in this commodity. The year 1969/70 was obviously an important one, however, in Indo-Soviet trade in mango products. Not only were the USSR's purchases of mango juice boosted from 1,966 tons in 1968/69 to 6,367 tons, but also 100 tons of jam, jelly, puree or pastes were imported, together with 15.4 tons of fruit preserved in syrup, some of which was probably canned mangoes. No exports to the USSR had been recorded in the group "mango jamaes, jellies, purees and pastes etc." for three years, and no "fruit preserved in syrup" for at least five years prior to 1969/70.

The USSR did not import from India any of the other mango products considered in this report in 1969/70. In 1963/64 there is a record of her buying 70 tons of chutneys and pickles, but there has been no trade in these commodities since then. There is no information available relating to any other sources of supply of mango products.

Table XV
USSR imports from India: mango products

	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Mango juice						
M. Tons	...	1,012	1,397	2,062	1,966	6,367
% of India's exports	...	75%	70%	62%	67%	84%
Mango slices in brine						
M. Tons	10	50	100	-	-	-
% of India's exports	2%	9%	37%	-	-	-
Fruit preserved in syrup						
M. Tons	-	-	-	-	-	15.4
% of India's exports	-	-	-	-	-	5%
Mango jams, jellies, purees, pastes, etc.						
M. Tons	...	118	-	-	-	100
% of India's exports	...	72%	-	-	-	27%
Tons TOTAL	...	1,180	1,497	2,062	1,966	6,482

... Not available
- Nil or negligible

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Prospects

It is virtually impossible to forecast the prospects for mango products in the USSR on the basis of past trade in view of the uncertainty attending the trade agreements involved. However mango juice does seem to have established itself well on the USSR market, and other products have been imported. Whether or not other suppliers can penetrate the market and would benefit by so doing depends on the nature of the trade and the trade agreements between the USSR and her supplier.

MIDDLE EAST

The Middle Eastern market for mango products is made up of the national markets of the following countries: Iraq, Saudi Arabia, Kuwait, Bahrein, Muscat, Qatar and Trucial Oman, South Yemen and Somalia.

India is the major source of supply, although South Africa has in recent years established for herself some substantial outlets in this area (8).

No statistics of South African exports to Middle East markets are available, but Table XVI shows imports from India by product and country between 1965/66 and 1969/70.

Mango juice

As can be seen from this table, mango juice is the major import. Quantities have risen steadily from 331 tons in 1965/66 to 1,127 tons in 1969/70, with the exception of 1967/68 when a record level of 1,236 tons were imported. The markets of both Bahrein, and Qatar and Trucial Oman, show consistent expansion over the period, from 2 tons to 110 tons, and from 7 tons to 232 tons respectively. Kuwait shows the most substantial annual average intake, at 424 tons, but her actual imports have fluctuated violently between 124 tons in 1965/66 and 955 tons in 1967/68. Saudi Arabia was the largest single market in 1969/70 with 560 tons and with the exception of the 1966/67 figure of 15 tons, this last-mentioned country's imports have risen each year from 163 tons in 1965/66.

Table XVI
Middle East imports from India: mango products

Product	Importing Country	1965-66 M. Tons	1966-67 M. Tons	1967-68 M. Tons	1968-69 M. Tons	1969-70 M. Tons
<i>Mango juice</i>						
	Bahrein	2	6	42	78	110
	Kuwait	124	433	955	446	162
	Muscat	4	3	3	23	6
	Qatar & Trucial Oman	7	9	36	97	232
	Saudi Arabia	163	15	180	182	560
	South Yemen	24	34	7	38	27
	Somalia	7	17	13	47	30
	TOTAL	331	517	1,236	911	1,127
<i>Mango chutney, pickles, without sugar</i>						
	Iraq	200	195	93	199	131
	Kuwait	10	32	13	47	120
	Qatar & Trucial Oman	3	5	4	10	13
	Saudi Arabia	53	29	12	16	1
	TOTAL	266	261	122	172	265
<i>Fruit preserved in syrup</i>						
	Kuwait	1.7	1.3	2.8	17.3	11.2
<i>Mango slices, dried</i>						
	Qatar & Trucial Oman	-	-	-	1.6	0.8
	South Yemen	3.1	-	-	-	-
	TOTAL	3.1	-	-	1.6	0.8
<i>Mango flour</i>						
	Kuwait	...	...	-	0.2	0.2
<i>Mango jams, jellies, pastes, purees, etc.</i>						
	Kuwait	18	4	20	7	3
	Qatar and Trucial Oman	-	2	-	20	2
	Saudi Arabia	16	6	11	21	80
	South Yemen	4	26	3	-	32
	TOTAL	38	38	34	48	117

... Not available
- Nil or negligible

Source:- *Foreign Trade of India*
Department of Commercial Intelligence and Statistics

Prospects therefore are generally good for mango juice in this area, the product being already well established, and the demand in certain important national markets showing consistent improvement.

Mango chutney, pickles without sugar (pickles)

Imports of mango pickles averaged 367 tons per annum between 1960/61 and 1964/65, from which point they steadily declined to 122 tons in 1967/68. From this level however they have risen to 265 tons in 1969/70, although this quantity does not compare with those obtaining in the first half of the 1960s.

Prospects therefore are difficult to assess. Thus Kuwait's imports show an improvement from 10 tons in 1965/66 to 120 tons in 1969/70, having declined only once during the period to 13 tons in 1967/68. Saudi Arabia's imports, however, have fallen away to negligible proportions, and Iraq's also appear to have levelled off.

Fruit preserved in syrup

Kuwait is the only importer of this group of products, and it is not known what percentage consists of mangoes canned in syrup. Average imports however only amount to 6.9 tons per annum over the period, and are thus of only very minor importance.

Mango slices, dried

Here again only an extremely limited market exists, South Yemen having imported 3.1 tons in 1965/66, and Qatar and Trucial Oman 1.6 tons and 0.8 tons in 1968/69 and 1969/70 respectively. No other trade occurred in this product over the period.

Mango jams, jellies, purees and pastes

Saudi Arabia is the major importer of this product group, quantities having risen steadily from 6 tons in 1966/67 to 80 tons in 1969/70. South Yemen's imports were also at their highest in 1969/70, at 32 tons, although this does not appear to be the extension of an enlarged intake pattern over previous years.

The total market, however, has increased, though not entirely consistently, from 38 tons in 1965/66 and 1966/67 to 117 tons in 1969/70, so any new supplier attempting penetration has the advantage of an expanding market.

EEC and SCANDINAVIA

As can be seen from Table XVII imports into this market from India, at present the leading supplier, increased steadily and substantially from 94 tons in 1965/66 to 267 tons in 1969/70. The United Kingdom is the second most important supplier, but quantities from this source have probably been declining in recent years.

Table XVII
EEC and Scandinavia imports from India: mango products

Product	Importing Country	1964/65 M. Tons	1965/66 M. Tons	1966/67 M. Tons	1967/68 M. Tons	1968/69 M. Tons	1969/70 M. Tons
Mango juice	Germany	...	3	-	1	9	28
Chutney and pickles, with sugar	Denmark	14	26	30	31	36	36
	Germany	40	28	44	54	83	96
	Netherlands	38	23	25	55	64	48
	Sweden	-	6	4	5	7	10
Slices in brine	Germany	2	-	-	-	-	19
Fruit preserved in syrup	Germany	...	8.3	15.1	2.8	8.6	23.8
	Netherlands	...	1.3	4.7	2.8	0.8	-
Mango, jams, jellies, purees and paste	Germany	-	-	0.6	0.1	2.2	6.5
ALL PRODUCTS	TOTALS	(94)	96	123	152	211	267

... Not available
- Nil or negligible

Source:- Foreign Trade of India
Department of Commercial Intelligence and Statistics

Mango chutney

Most of the trade with this market consists of mango chutney, and Germany is the major importer, getting most of her supplies in the past from the United Kingdom. It is believed however that a sizeable proportion of her imports from this source were consumed by the British Army of the Rhine. The considerable reduction in size of this force in recent years can therefore be assumed as in part accounting for the falling off of supplies from the United Kingdom. Over the same period, India has been attempting to increase her penetration of the German market with mango products exported direct. This has met with some success, as shown by the steady increase in German imports of chutney from India, rising from 28 tons in 1965/66 to 96 tons in 1969/70 (see Table XVII).

In 1969 the EEC countries introduced two new categories into their trade returns — 'Mango chutney' and 'Mango sauce' (or liquid mango chutney), the latter being grouped with condiments or seasonings. Trade in these categories is shown in Tables XVIII and XIX respectively, and a summary of both appears in Table XX. It should be noted that the totals shown in Table XX include considerable double counting as substantial internal trade exists between EEC member countries, as disclosed in Tables XVIII and XIX.

On the basis of only two years statistics it is clearly not possible to deduce much about overall trends with regard to such factors as changes in the sources of supply. There follow, however, some comments based on the data which is at present available.

Table XX shows that combined imports by EEC countries under both categories were lower in 1970 than in 1969; this is not taken as indicating a decline in demand, but is regarded rather as a sign that the market is not in a rapid expansionary phase.

Germany is the largest single market. Her imports of chutneys increased in 1970 compared with 1969, but her imports of mango sauces fell away. Combined imports remained steady at 199 tons in 1969 and 193 tons in 1970, of which India supplied 105 tons in both years and the United Kingdom 66 tons in 1969 and 53 tons in 1970. It would appear, therefore, that the United Kingdom is becoming of less importance as a source of supply, a fact which may to some extent be attributed to the decline in the number of British troops stationed in Germany who, according to Athisayam (6), provided a significant market in 1968. Germany's re-exports of these products are negligible.

Italy is the second most substantial importer, particularly of chutneys. Unfortunately little detail is available regarding her sources of supply, but it does appear, from a study of the exports section of Table XIX, that Italy imports mango chutney mainly for reprocessing into sauces, since her exports of this latter commodity are quite sizeable and considerably exceed her imports.

The Netherlands is an important importer of both chutneys and sauces, and she maintains a substantial export/re-export trade in sauces. As far as imports are concerned the United Kingdom remains her major source of supply, followed by India. The explanation for the relative importance of the Netherlands market compared with her comparatively small population is that she has always had traditionally close ties with tropical countries and many of her people have passed extended periods of their lives overseas. The immigrant population is also sizeable, and there are many Chinese and especially Indonesian restaurants which provide a regular outlet for both mango chutney and sauces.

Belgium offers only a small market, trade being conducted mainly with other EEC countries.

The French market is extremely limited, particularly when one considers that her population is approximately the same size as that of Italy and Germany. Indeed imports of both chutneys and sauces combined only amounted to an average of less than 10 tons per annum over the two years for which statistics are available.

Table XVIII
Mango chutney: trade of EEC countries

	Belgium/Luxembourg		France		Germany		Italy		Netherlands	
	1969 M. Tons	1970 M. Tons	1969 M. Tons	1970 M. Tons	1969 M. Tons	1970 M. Tons	1969 M. Tons	1970(a) M. Tons	1969 M. Tons	1970 M. Tons
IMPORTS : TOTAL	19.4	6.8	5.0	2.0	37.7	54.2	73.7	40.6	27.0	13.0
of which from:-										
Belgium/Luxembourg	-	-	...	...	...	...	...	...	-	...
Netherlands	...	...	...	...	11.6	9.9	...	...	-	-
EEC countries, unspecified	18.4	6.6	...	...	-	-	...	...	...	...
India	-	-	...	...	23.9	43.2	2.5	...	23.0	...
United Kingdom	-	-	...	...	...	-	...	...	4.0	11.0
Unspecified countries	1.0	0.2	5.0	2.0	2.2	0.1	71.2	40.6	-	2.0
EXPORTS : TOTAL	2.2	1.5	-	-	-	-	11.8	18.7	5.0	1.0
of which to:-										
Belgium/Luxembourg	-	-	-	-	...	...	4.0	...	2.0	-
Germany	...	...	-	-	-	-	0.3	...	3.0	-
France	...	...	-	-	-	-	0.3	...	-	-
EEC countries, unspecified	2.2	1.5	-	-	-	-	-	...	-	-
United States of America	-	-	-	-	-	-	6.8	...	-	-
Unspecified countries	-	-	-	-	-	-	0.4	18.7	-	1.0

- nil or negligible

... not specified separately

(a) From December summary, giving totals only

Sources:- Official Trade Reports of EEC countries

Note:- Commodity not separately specified before 1969

Table XIX
Mango sauces, condiments and seasonings, liquid: trade of EEC countries

	Belgium/Luxembourg		France		Germany		Italy		Netherlands	
	M. Tons	1970	M. Tons	1969	M. Tons	1970	M. Tons	1969	M. Tons	1970
IMPORTS : TOTAL	8.6	11.2	6.0	6.0	161.0	138.9	7.1	9.6	46.0	50.0
of which from:-										
Belgium/Luxembourg	-	-	...	-	...	-	...	...	-	1.0
Netherlands	...	...	...	-	10.6	10.1	...	...	-	-
EEC countries, unspecified	4.0	3.0	1.0	-	0.4	-	...	...	-	-
United Kingdom	...	...	...	...	65.5	52.7	1.0	...	33.0	20.0
India	...	...	...	...	81.5	61.6	0.3	...	13.0	28.0
France	-	-	-	-	-	-	3.8	...	-	-
Unspecified countries	4.6	8.2	5.0	6.0	3.0	14.5	2.0	9.6	-	1.0
EXPORTS : TOTAL	1.4	11.5	6.0	-	-	1.2	75.1	35.6	23.0	24.0
of which to:-										
Germany	...	...	...	-	-	-	60.8	...	22.0	23.0
France	...	...	-	-	-	...	3.7	...	-	-
Netherlands	...	...	...	-	-	...	6.3	...	-	-
EEC countries, unspecified	1.4	1.2	6.0	-	-	1.2	-	...	1.0	1.0
Unspecified countries	-	10.3	-	-	-	-	4.3	35.6	-	-

- nil or negligible
... not specified separately
(a) From December summary, giving totals only

Sources:- Official Trade Reports of EEC countries

Note:- Commodity not separately specified before 1969

Table XX
Mango chutneys and sauces: imports by EEC countries

Importing country	1969		1970	
	Chutney M. Tons	Sauce M. Tons	Chutney M. Tons	Sauce M. Tons
Belgium/Luxembourg	19.4	8.6	6.8	11.2
France	5.0	6.0	2.0	6.0
Germany	37.7	161.0	54.2	138.9
Italy	73.7	7.1	40.6	9.6
Netherlands	27.0	46.0	13.0	50.0
TOTALS	162.8	228.7	116.6	215.7
TOTAL, BOTH PRODUCTS	391.5		332.3	

Sources:- Official Trade Reports of EEC countries

In so far as Scandinavia is concerned both Denmark and Sweden obtain small quantities of mango chutney from India, and the overall trend in imports into both these countries appears to be upwards. Quantities remain small, however, Denmark accounting for 36 tons in 1969/70, Sweden for 10 tons.

Mango juice

Germany offers the only sizeable market for this product, her supplies coming entirely from India. Imports have increased quite rapidly recently to 28 tons in 1969/70, from only 3 tons in 1965/66 and nil in 1966/67.

Although it is impossible to extrapolate a valid forecast of future growth of this market from the data presently available, it should be noted that fruit juices as a whole are of considerable and increasing popularity in Germany, per capita consumption having increased from 9.3 pints in 1959/60 to 16.8 pints in 1969/70 (9). With increased and sustained promotional activity and reduced prices, prospects for the continued expansion of sales of mango juice could therefore be quite favourable.

Mango jams, jellies, purees and paste

The only market for these products occurs in Germany, which imports very limited quantities from India. Although these imports appear to be increasing slowly, sales remain small and prospects generally do not appear to be very promising.

Mango slices in brine

In 1964/65 Germany imported 2 tons of brined slices from India, then made no further purchases until 1969/70 when 19 tons were bought. As can be seen, trade is extremely limited and spasmodic. There is no evidence to suggest that an established demand has been developed.

No other European country imported mango slices in brine in significant quantities at any stage during the period under consideration.

Mangoes in syrup

Germany provides the largest national market for this product importing supplies from India, South Africa and Ceylon.

Most of the product group imported from India and subtitled "fruit preserved in syrup" on Table XVII consists of canned mangoes in syrup in so far as European

markets are concerned. German imports from this source amounted to 23.8 tons in 1969/70, and although annual quantities have been erratic the underlying trend appears to be upward.

On the German market however this product is very expensive. At import level in 1970, for example, mangoes in syrup were selling at between £8.30p and £9.60p per case of 24 x A2½'s, for which the corresponding asking price for one of the more expensive volume lines, namely United States fruit cocktail in heavy syrup, was approximately £2.30p (10).

The same report states that the Netherlands also imports canned mangoes, buying from India, South and East Africa. Quantities however are extremely small, and indeed there were no imports at all from India in 1969/70 (Table XVII). Only two specialised importers are known to sell canned mangoes to the retail trade in the Netherlands. In 1969 the largest of these firms imported an estimated 1,500 cases of 24 x 16 oz cans (16 tons approx) from South Africa (11). Sales however remain static, increased promotion leading to product familiarity and coupled with overall price reductions being pre-requisites for any increase in demand.

NORTH AMERICA

Both the United States and Canada provide established markets for certain mango products. Supplies are received from a variety of countries, though India and Jamaica are believed to be the major sources. Official import statistics are totally lacking, though there are some reported data for 1967, which appear in Table XXI.

Table XXI
United States of America: imports of mango products in 1967

Product	Source	Quantity M. Tons
<i>Mangoes, fresh or canned</i>		
	Mexico	808.6
	Haiti	541.0
	Jamaica	90.7
	Formosa	67.5
<i>Mango paste and pulp</i>		
	Guatemala	34.7
	Venezuela	36.6
	India	1.4
	Jamaica	0.9

Source:- *Fruits* (1968) 23 (6), 341-343.

Imports from India and Jamaica are shown in Table XVIII.

United States of America

It is probable that a high proportion of those imports shown under the heading 'Mangoes, fresh or canned' in Table XXI consist of fresh fruit. Venezuela and Guatemala were the major suppliers of mango paste and pulp in 1967, with exports of 36.6 tons and 34.7 tons respectively. In 1969, Jamaica replaced India as the major supplier of mango products to the United States market, supplies from India amounting to 176.5 tons and from Jamaica, 232 tons. (See Table XXII.)

The products dominating trade with India are mango chutneys and pickles containing sugar. Here, average imports between 1965/66 and 1969/70 amounted to 171 tons per annum. Trade in chutneys and pickles without sugar has been increasing steadily, from 14 tons in 1966/67, to 22 tons in 1969/70, although quantities

Table XXII(a)
United States of America and Canada: imports from India of mango products

	1965/66 M. Tons	1966/67 M. Tons	1967/68 M. Tons	1968/69 M. Tons	1969/70 M. Tons
<i>Mango chutney, pickles with sugar</i>					
United States	242	151	128	183	153
Canada	26	17	26	31	30
<i>Mango chutney, pickles without sugar</i>					
United States	14	14	16	18	22
Canada	5	5	11	8	12
<i>Mango slices, dried</i>					
United States	-	0.1	0.1	0.3	1.4
<i>Mango flour</i>					
United States	...	...	0.1	0.5	0.1
Canada	...	...	0.3	0.8	0.7

Source:- Foreign Trade of India, Department of Commercial Intelligence and Statistics

Table XXII(b)
United States of America and Canada: imports from Jamaica of mango products

	1964	1965	1966	1967	1968	1969
<i>Mangoes in brine or syrup, whole or sliced</i>						
United States: Tons	89.7	93.6	79.2	94.5	101.2	232
<i>Mango pulp</i>						
United States: Tons	2.3	-	-	-	-	-
Canada: Tons	0.2	1.6	14.1	0.8	-	-

... Not available
- Nil or negligible

Source:- External Trade Bulletin Department of Statistics

remain small. Average annual trade in all varieties of chutneys and pickles has increased from 62 tons between 1960/61 and 1964/65 to 188 tons between 1965/66 and 1969/70. However, imports of the major commodity – chutney (ie with sugar) – do not appear to be rising at present: indeed they fell from 183 tons in 1968/69 to 153 in 1969/70. Other products imported in very limited quantities from India are dried mango slices and mango flour.

All imports from Jamaica consist of mangoes canned in syrup or packed in brine. Quantities imported have increased steadily from 89.7 tons in 1964 to 232 tons in 1969, with the exception of a slight fall in 1966 to 79.2 tons. The market for these products has more than quadrupled in size during the sixties, from a 1960-1962 average of 56.5 tons, and there is as yet no reason to suppose that saturation point has been reached.

Canada

Canada’s market is considerably smaller than that of the United States. Details are known only of her trade with India, which is believed to be the major source of her supplies. No imports are at present being received from Jamaica, although small quantities of mango pulp were traded up to 1967.

Chutneys and pickles are Canada’s only import of any consequence from India. Quantities increased slowly, but fairly steadily, from 31 tons in 1965/66 to 42 tons in 1969/70, and there should be further room for expansion. Mango flour is also supplied by India, though in annual quantities amounting to less than one ton.

Structure of the trade in the United Kingdom

This section deals only with the United Kingdom – the leading Western European market.

Mango slices may be dealt with separately from the other items studied in this report. The bulk of this commodity is imported direct by the major processing firms – Brand-Sharwood Ltd and Rayner and Co Ltd, either on fob or cif terms according to particular circumstances. However a few merchants also handle this product.

The other items are consumer goods, with the exception of some grades of chutneys which are used for reprocessing, though some are bulk packed and require repacking. They are therefore handled through traditional channels of distribution. Classically the distribution channel is: importer-wholesaler-retailer. There is some overlap between importers and wholesalers and indeed some firms undertake both functions. More important however is the fact that there is considerable specialisation within the import/distribution sector on the basis of the total volume of trade in any commodity. Thus there is a group of importers/wholesalers/retailers concerned mainly with large volume lines (eg canned pineapples, pears, peaches), another group handling moderate volume lines and a further group which handles small volume lines. The margins made at each stage of the marketing chain increase as volume of trade in the commodity decreases.

The products studied in this report are handled by firms trading in moderate volume lines, namely lines which are handled in quantities aggregating 2,500 to 20,000 cases per annum for the country as a whole where canned or bottled goods are concerned. Although not all the commodities considered measure up to this criterion they are nevertheless handled by the same group of firms, as the products are largely destined for the same outlets as those that do, and it is therefore convenient for the firms concerned to handle them.

A relatively small number of firms are actively engaged in the importation of mango products, and there are three main reasons for this:

1. The aggregate trade is too small for more than a few firms to make an adequate return.
2. Supplies are obtained almost exclusively from five main countries or areas – India, Jamaica, South Africa, South East Asian countries (principally China) and Australia, and traders who have traditional ties with these parts of the world, as well as others who have ethnic links, have established themselves.
3. Importers have found that specialised retail outlets require specialised import/wholesale methods, and importers of 'volume lines' have in the majority of cases found it not worth their while to make the necessary adjustments.

Margins taken by importers, wholesalers and retailers on these products tend to be higher than those taken on more substantial 'volume lines'. The following is a rough guide to margins pertaining to the products under consideration:

Importers	5-10%
Wholesalers	10-15%
Retailers	25%+

Goods are usually traded on cif terms.

Tariffs

There follows a summary of trade tariffs as they apply to mango products imported into the United Kingdom, EEC and the United States.

1. The United Kingdom

Imports into the United Kingdom of all mango products from Commonwealth countries and South Africa enter duty free.

The following rates apply *ad valorem* to imports from all other sources from 1.1.72. Preferential rates apply for developing countries, all their products except jams, jellies, purees, and pastes (BTN category 20-05) entering duty free.

Dried mango slices	5%
Mango chutneys, pickles, sauce (liquid), flour	10%
Juice, jams, jellies, purees, paste	10%
Mangoes in brine, syrup, and pulp	15%

2. The EEC

The following tariff rates shown in Column I apply to imports from third countries of mango products into the EEC, and have had effect since 1 January 1972, except that developing countries have been granted some preferences, shown in Column II, with effect from 1.7.72.

	I	II
Dried mango slices	6%	6%
Mango slices in brine	11%	8%
Mango flour	13%	10%
Mango chutneys and pickles	Free	Free
Mango jams, jellies, purees and paste	30% (a)	24% (a)
Mangoes canned in syrup and mango pulp:		
In containers of less than 1 kg	24% (a)	19% (a)
In containers of more than 1 kg	22% (a)	18% (a)
Mango juice:		
Containing added sugar	21% (a)	17% (a)
Not containing added sugar	22%	18%
Mango sauce (liquid)	Free	Free

Notes:— All rates are *ad valorem*

(a) :— denotes product to which a sugar surcharge may be added to the basic duty rate.

3. The United States

The following MFN (Most Favoured Nation) tariff rates apply to imports of mango products into the United States, which have had effect from 1 January 1972:

Mangoes, fresh, or prepared or preserved	3.75 cents per lb
Mango paste and pulp	7% <i>ad valorem</i>
Mango jams and jellies	5% <i>ad valorem</i>
Mango juice	3% <i>ad valorem</i>
All fruit and vegetable sauces	7.5% <i>ad valorem</i>

Rates which applied before the preferences given to developing countries came into operation were not in general specifically selective towards mango products as against other fruit based products; the United Kingdom and EEC, however, conferred benefits on Commonwealth and associated countries respectively. Recently introduced reductions for developing countries should ease suppliers' problems, although those applied by the EEC are only marginal.

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8. Private communication
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10. INTERNATIONAL TRADE CENTRE UNCTAD/GATT 1971. *The markets for selected exotic fruit products in the United Kingdom, the Federal Republic of Germany, Switzerland and the Netherlands*. Geneva: International Trade Centre UNCTAD/GATT, pp. 86-87.
11. INTERNATIONAL TRADE CENTRE UNCTAD/GATT 1971. *The markets for selected exotic fruit products in the United Kingdom, the Federal Republic of Germany, Switzerland and the Netherlands*. Geneva: International Trade Centre UNCTAD/GATT, p. 148.

Appendix

Firms trading in mango products in the United Kingdom

Note: The following list gives the names of some of the firms which are known to the Tropical Products Institute to be trading in these commodities, but the list should not be regarded as exhaustive. Inclusion in the list does not imply that TPI has any knowledge of the financial standing of the firms.

The products with which each firm deals are also shown.

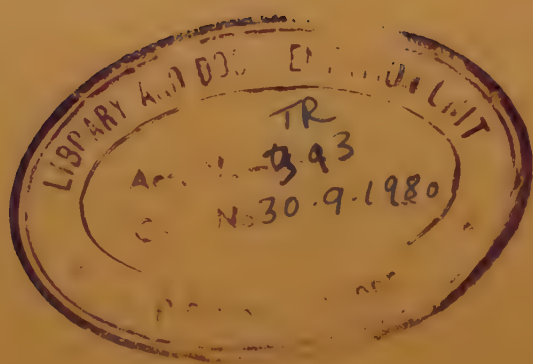
Biddle Sawyer and Co Ltd Plantation House Mincing Lane London EC3	Mangoes in syrup
Bombay Emporium Ltd Wallis Road London E9	Mangoes in syrup, juice, nectar, pulp, dried slices, powder chutney, pickle, slices in brine
Brand- Sharwood Ltd Cerebos House Hartlepool County Durham	Slices in brine
Briggs Abbott and Co 16 Finsbury Circus London EC2M 7DD	Slices in brine, chutney and pickles
G Costa and Co Ltd Staffordshire Street London SE15	Mangoes in syrup
Dein Bros. (Food Importers) Ltd Sea Isles House Frogmore, Park Street St Albans, Herts	Mangoes in syrup
Enco Products (London) Ltd 71 Fortess Road London NW5	Mangoes in syrup
Evans, Gray and Hood Ltd 110 Cannon Street London EC4	Mangoes in syrup, pulp, juice and nectar, chutney and pickles
Grewal, Basi and Co 15/17 Artillery Lane London E1	Mangoes in syrup, pulp, chutney and pickles

Petty, Wood and Co Ltd 12 Eastcheap London EC3	Mangoes in syrup
Pollshon Produce Co Ltd Pollshon House 96 Wardour Street London W1	Mangoes in syrup
Rayner and Co Ltd Commercial Road London N18	Slices in brine
Frank Roberts of London Ltd Fro-Lon House Station Way London SE15	Mangoes in syrup

G75

Cassava processing: commercially available machinery





G75

Cassava processing: commercially available machinery

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September 1972

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Foreign and Commonwealth Office (Overseas Development Administration)

This report was produced by the Tropical Products Institute, a British Government Organisation which helps developing countries to derive greater benefit from their renewable resources.

It specialises in post-harvest problems and will be pleased to answer requests for information and advice. Reports such as this one are often written as the result of an enquiry.

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PREFACE

The Tropical Products Institute has in preparation a number of inter-related reports on the production, processing and marketing of cassava and cassava products.

This report, the third in the series, lists some of the commercially available machinery used for processing cassava for the production of dried cassava products such as starch, chips, flour, pellets and gari.

Earlier documented studies in the series are 'Selected bibliography on cassava (*Manihot esculenta* Crantz)' (*Trop. Prod. Inst. Rep.* G51, 1970) and 'Cassava storage – a review' (*Trop. Sci.* 1972, **14** (2), 131 - 148).

ACKNOWLEDGEMENTS

Thanks are due to the manufacturers who provided information for this report. However, we would point out that mention of particular manufacturers does not imply a recommendation of their product to the exclusion of others which may also be suitable.

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Introduction

The plant commonly called cassava in English speaking countries of Africa; *manioc* in Franocophone Africa; *manihot*, *mandioca*, *yuca* in Latin America; and *tapioca* in tropical Asia, *Manihot esculenta* Crantz is widely distributed in tropical countries throughout South and Central America, Africa, and Asia. According to the FAO Production Yearbook (1970) global production in 1969 was estimated at just over 90 m. tons as shown in Table I.

Table I
World production of cassava in 1969

	(thousand metric tons)
North and Central America	612
South America	34,237
Asia	19,951
Africa	36,035
Oceania (Pacific countries)	123
Total	90,958*

Cassava, either fresh or processed is a major staple food, i.e., a source of carbohydrate for millions of inhabitants in the tropics. In addition to many traditional food uses, processed cassava products also find use in other fields, e.g., animal feedingstuffs and food industries, breadmaking in many countries, paper and textile industries, adhesives and dextrans. The starch also finds minor outlets in surgical dressings, flocculents in mining, drilling fluids in oil boring, and binders for ceramics.

The highly perishable nature of fresh cassava and the necessity to process the tubers soon after harvest into some form of dried products has been discussed in an earlier paper†. Cassava starch is obtained by small-scale wet extraction processes and is also manufactured industrially on the factory scale. A large proportion of cassava based foods, even in subsistence economies, are processed in some way for example, fermented foods such as *gari* in West Africa and *farinha da mandioca* and *couac* in Brazil. Chips are produced by peeling the tubers, then chipping or slicing into suitable sizes, followed by sun drying. Flour is the milled product obtained by grinding chips in a mortar, stone mill or hammer mill. Pellets are produced (in Thailand) by grinding chips and dried broken roots into a meal. The meal is then treated and compressed in a conventional pelleting plant, to produce cylindrical shaped pellets of the required dimensions.

*Excludes China which is also a large producer of cassava. (Int. Tr. Centre, 1968. UNCTAD/GATT, Geneva. 'The Markets for manioc as a raw material for compound animal feedingstuffs. The Fedl. Republic Germany, The Netherlands and Belgium.'))

†Ingram, J.S. and Humphries, G.R.O. (1972). Cassava storage — a review. *Trop. Sci.* 14 (2) 131 - 148.

The technology of cassava starch production is quite advanced and on the factory scale modern machinery is used. Principal pieces of apparatus consist of root washer and peeler, rasper (disintegrator), roto sieves for starch extraction, centrifugal pumps and concentrators for starch separation, vibro-screens and starch purifiers, dehydrating centrifuge, flash dryer, sifting and bagging equipment. There are several well known sources of supply of such machinery in Europe. Some of the large engineering companies manufacture complete plant for the process whilst others specialize in relevant individual items of equipment only. They are all specialists in the field and their machinery is used for processing starch from different raw materials, including cassava. Modifications may sometimes have to be made to apparatus when a factory is installed but developments can be made from the basic design.

Standard or special purpose machinery for the production of other cassava products such as chips, flour, pellets, gari and tapioca is not so well known. The different operations involved in the preparation of this group include peeling, chipping or slicing, grating, drying, milling and pelleting, and in many cases traditional or partly traditional methods are still practised. The respective processes are relatively simple and much of the preparation is done manually or with the aid of simple locally designed equipment. However, with advancement of urbanisation, living standards and technology in developing countries, there is a more widespread interest and demand for special modern machinery to deal with these products. Pulverising dried cassava presents no problems but for chipping, grating and drying, standard machinery of European manufacture is not so readily available. In Brazil however there are special machines designed to rasp (grate), filter-press and grind cassava and so far as it is known these machines are manufactured in Pernambuco. The power driven rasps have 2 capacities, viz., 800 kg/hour and 1500 kg/hour and cost respectively \$60 and \$300. A hand operated filter press (for expressing fruit water) which can press 300 kg/hour costs \$100. The motor driven grinder handles 300 kg/hour and costs about \$100*.

As general information on sources of suitable commercial machinery for the production of processed cassava products is not easily traced in the literature, a list of some machinery manufacturers, arranged in alphabetical order, is given. They have been cited as typical in the field and in the case of potential chipping, grating and drying machinery, relevant information is added. Any queries regarding performance and efficiency of machines for specific operations should be referred to the firms concerned.

It is of interest to mention also that several experimental machines and techniques for peeling, chipping or slicing, grating and drying cassava are described in the scientific literature; these will be reviewed in a separate paper. Meanwhile some references on this subject are also given (see p. 7).

*Univ. of Georgia (1972). A literature review and research recommendations on cassava. *AID Contract No. csd/2497.*

Machinery manufacturers and suppliers

STARCH PLANT

Alfa-Laval Limited (of Tumba, Stockholm, Sweden),
Great West Road,
Brentford,
Middlesex,
England

Braunschweigische Maschinenbauanstalt,
3300 Braunschweig,
Postfach 295,
Fedi Rep. Germany

Continental Engineering Ltd,
Lutmastraat 2,
Amsterdam,
Netherlands

Dorr-Oliver Co. Ltd, (of Amsterdam, Netherlands)
Norfolk House,
Wellesley Road,
Croydon, Surrey,
England

Adolf Hübrich,
Maschinenbau,
2000 Hamburg 1,
Ernst — Merckstrasse 12-14,
Fedi Rep. Germany

Maquina D'Andrea,
Rua Jose Bonifacio,
29-9° — Sala 91,
Sao Paulo,
Brazil

Nivoba N.V.,
Industrie Weg 1,
Veendam,
Netherlands

Starcosa GmbH & Co.,
305 Wunstorf (near Hanover)
2 Industriestrasse,
Fedi Rep. Germany

Stärketechnik Grindel & Co.,
2 Hamburg 20,
Heinickerstrasse 4,
Fedl Rep. Germany

Westfalia (Separators) Ltd,
Oelde, Westfalia,
Fedl Rep. Germany

Otto Wolf Co.,
63 Commerce Street,
Chambersburg,
Pennsylvania,
U.S.A.

PELLETING PLANT

Amandus Kahl Nachf,
2057 Reinbek,
Hamburg,
Dieselstrasse 5-9,
Fedl Rep. Germany

Plant is operating in Thailand.

R.A. Lister & Co. Ltd,
Dursley,
Gloucester,
England

Experimental cassava pelleting trials
are in progress.

Richard Sizer Ltd,
Wilmington, Hull,
England

This firm has pelleted cassava
satisfactorily under experimental
conditions.

Zell-Lignin Verkaufsgesellschaft GmbH,
4000 Dusseldorf-Oberkassel 1,
Hansa-Allee 159,
Fedl Rep. Germany

Plant is operating in Thailand.

GARI (OR FARINHA DE MANDIOCA) PLANT

Maquina D’Andrea,
Rua Jose Bonifacio,
29-9° — Sala 91,
Sao Paulo,
Brazil

Newell Dunford Engineering Ltd,
143 Maple Road,
Surbiton, Surrey,
England

CHIPS, FLOUR, GARI PROCESSING MACHINERY

Slicer/chipper

S. Corbett & Son,
Park Street Works,
Wellington,
Shropshire,
England

‘Cambrian’ root cutter is claimed to
be suitable for cassava. Minimum
capacity is 1 ton per hour, maximum
10 tons per hour.

J.W. Greer & Co. Ltd,
(subsidiary of the Joy Manufacturing Co. USA)
3-5 Tribune Street,
Sittingbourne,
Kent,
England

According to the firm 'Urschell' model 'H' is installed in some South American countries for production of cassava chips. It is presently being tried out in W. Africa also. Maximum capacity is 30,000 lb. per hour i.e. approx. 13 tons per hour.

Grater

Simon Barron Ltd,
Bristol Road,
Gloucester,
England

The 'Barron' cassava grater is a simple drum type rasper with a capacity of 200-300 lb. per hour, depending on the feed rate.

S. Corbett & Son,
Park Street Works,
Wellington, Shropshire,
England

'Cambrian' grater is claimed to be suitable for grating cassava. Power operated, capacity is reported to be minimum 1 ton per hour, maximum 10 tons per hour.

Robt Friess KG,
Landmaschinen Fabrik,
Malmsheim Krs,
Leonberg, Nr Stuttgart,
Fedl Rep. Germany

The 'Friess' consists of high speed revolving blades capable of grating up to 2 tons of cassava per hour.

ScotMec Works,
Ayr,
Scotland

The cassava mash produced by a ScotMec hammer mill has been reported suitable for gari manufacture.

Drier

Alvan Blanch Development Co. Ltd,
Chelworth Manor, Nr. Malmesbury,
Wilts,
England

The firm is confident that their machinery can be adapted to dry cassava.

Nuway Benson Ltd,
Temeside Works,
Ludlow, Shropshire,
England

The firm states that their crop drier is suitable for drying cassava. The 'Mini-Drier' used in conjunction with locally made trays is specially sized for small installations, up to 2,000kg (2 tons) per day.

E.H. Bentall & Co. Ltd,
Maldon, Essex,
England

It is suggested that their 'Delta' 2ton batch tray grain drier might be suitable for cassava chips.

Newell Dunford Engineering Ltd,
143 Maple Road,
Surbiton, Surrey,
England

A cassava chip drier is presently being tried out in W. Africa.

R.A. Lister & Co. Ltd,
Dursley,
Gloucestershire,
England

The Lister Moisture Extraction Unit is a reversible air-flow bin system used for all crops with high initial moisture content. It is used in Ghana to dry cassava. Minimum output of 2 tons per day can be increased to 7.5 tons per day with additional heaters.

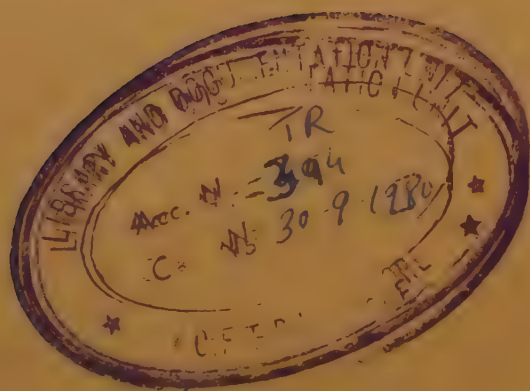
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G76

The artificial drying of pimento berries





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The artificial drying of pimento berries

G. R. Breag, L. D. G. Coward, J. Nabney
and F. V. Robinson

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Summaries

SUMMARY

The artificial drying of pimento berries

Data obtained from laboratory and field trials are used to recommend conditions for the hot air drying of green pimento berries to give a product with flavour, colour and physical characteristics indistinguishable from the traditional sun dried pimento berries.

A small scale drying unit is shown in detail in the first appendix while the second appendix describes a suitable moisture meter.

SOMMAIRE

Le séchage artificiel des baies de la toute-épice

Les données relevées des essais de laboratoire et sur le terrain sont utilisées en recommandant les conditions de séchage à air chaud des baies vertes de la toute-épice dans le but de donner un produit possédant une arôme, couleur et caractéristiques physiques que l'on ne peut distinguer des baies des toute-épices traditionnelles séchées au soleil.

On a exposé un sécheur à petit rendement en détail dans la première annexe, et dans la deuxième annexe on décrit un convenable mètre d'humidité.

RESUMEN

El secado artificial de las bayas de la pimienta de Jamaica

Datos obtenidos de los ensayos de laboratorio y de campo son utilizados para recomendar las condiciones de secar en aire caliente las bayas verdes de la pimienta de Jamaica de manera que se obtenga un producto de sabor, color y características físicas indistinguible de las bayas secadas en el sol tradicionalmente.

Una unidad para secar en pequeña escala se muestra en detalle en el primer anexo y en el segundo anexo se describe un apropiado medidor de humedad.

The artificial drying of pimento berries

The pimento berries of commerce are the dried immature berries from the tree *Pimenta dioica* (L.) Merrill.

The fresh picked berries contain about 65 per cent moisture and therefore need to undergo some form of drying process to bring the level down to the required figure of 12 per cent moisture.

Sun drying

Normally this is achieved by spreading the berries out on large concrete courts or barbecues to dry in the sun. The berries are occasionally turned by raking so as to obtain even browning. This form of drying takes from three to twelve days, depending on the prevailing weather conditions.

In some cases this drying time may be reduced by piling the berries in a heap and allowing them to 'sweat' for a few days. This is the so-called 'fermentation' process, but is more probably a limited breakdown of plant material with the release of carbon dioxide, water and heat. It is not an essential requirement for production of the odour and flavour of the spice in the berry. However, it almost certainly increases the drying rate, and this could be attributed to the breakdown of the cell structure of the berry and the consequent increase in the rate of diffusion of water to the outer surface. Another benefit from this 'sweating' process is the known¹ rapid breakdown of chlorophyll (the natural green plant pigment) in conditions of moderate temperature and high humidity, leading to a more even brown colour. A note of warning is necessary, however, for if this 'sweating' is overdone (say more than three days) the final dried berry is extremely brittle and easily broken; in addition to this mould usually begins to appear. These are harmful effects which could result in the rejection of the consignment by the Produce Inspector.

Artificial drying

During the last few years there has been some attempt to dry the berries artificially. The benefits from drying this way are a shorter drying period unaffected by weather conditions, and a reduction in the broken berries, dust, dirt and bacteria that are an inevitable consequence of the barbecue type of drying; risk of pilferage is also reduced. Breag² *et al* have recently shown that artificial air drying is a profitable operation.

There are a number of problems inherent to spice drying that do not occur in normal agricultural crop drying. The most important of these results from the fact that some of the compounds responsible for the properties of the spice are in the form of a volatile essential oil and this oil must not be lost or altered in any way from that found in the familiar sun dried product. Additionally the

product after drying must not only have the same flavour and odour but must also look the same as the sun dried product, that is an even brown colour. It is possible to dry agricultural products in such a way that they retain their fresh green colour, but this would be undesirable with pimento berries.

To achieve these objects the Tropical Products Institute in collaboration with the Jamaican Agricultural Department and, in the later stages, the University of the West Indies carried out some careful experiments on artificial air drying of pimento.

The first experiments were at laboratory and pilot scale and were designed to find out what temperature and air flow conditions were needed to dry the spice to a brown colour without loss of spice flavour and odour content.

These parameters were clearly established as:—

1. A temperature range of 70°C to 75°C. At temperatures above this there were indications that spice oil content could be lost. At temperatures below this range the berries begin to dry an uneven green to brown colour.
2. The air flow needed to be only about 50 cubic feet per minute.
3. It was also shown by detailed analysis that when berries were dried under these conditions there was no apparent change in the constitution of the spice.

Samples of the dried berries submitted to representatives of the spice trade in Britain were found to be acceptable in colour and aroma. The flavour and odour character were indistinguishable from standard pimento.

Having established the conditions for drying pimento a drier of a suitable capacity for the average producer was designed and tested. This drier is described and shown in Appendix 1. An indirect fired type was used as hot combustion gases from direct fired heaters are not desirable for spice drying since they may cause contamination. The time necessary to dry a charge of 550 lb of fresh pimento down to 12 per cent moisture was found to be eight hours in this drier.

Mention may be made at this point of a moisture meter capable of determining the residual moisture of the berries. This facility would be particularly advantageous when drying 'sweated' or partially dried pimento. This meter offers considerably more precision to this determination than the traditional 'shaking' method. Details of this meter may be found in Appendix 2.

Recommendations for drying pimento

1. Fresh green or 'sweated' pimento may be artificially air dried using the drier described in the text or a similar drier provided that it is indirect fired, can produce drying air temperatures of 70°C to 75°C and has provision for strictly controlling the temperature between these limits.
2. The drying time would normally be 8 hours for a 550 lb load.

These conditions apply only to pimento; should the drier be considered for other crops, additional information should be sought.

Information on the technical experimental details of the project may be found in the *Proceedings of the Conference on Spices, London 1972* obtainable from the Tropical Products Institute ².

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2. BREAG, G., COWARD, L.D.G., NABNEY, J. and ROBINSON, F.V. 1973. Artificial drying of Jamaican pimento. *Proc. Conf. Spices, London 1972*, ed. J. Nabney and W.S.A. Matthews. London: Tropical Products Institute, pp. 149-157. (In the press).

Construction and technical details of the drying unit

The technical specification for the drier used, a Nu-Way Benson Indirect Zeta with time clock and thermostat to control the limiting temperature, is shown below:—

1. Heat Output 53 kW (180,000 Btu/h)
2. Air Delivery Hot 75°C (170°F) $8.5 \times 10^{-1} \text{ m}^3 \text{ s}^{-1}$ (1,800 CFM)
Cold 20°C (70°F) $7.2 \times 10^{-1} \text{ m}^3 \text{ s}^{-1}$ (1,500 CFM)
3. Available Outlet Pressure (Ducted Model) 62N/m² (0.25 wg)
4. Nozzle Discharge Velocity 7.5 m/s (1,500 FPM)
5. Approx. Throw 30m (100') (TV $5.0 \times 10^{-1} \text{ m/s}$)
6. Temp. Rise Through Unit 55°C (100°F)
7. Approx. Area Heated Assuming 40W/m³, 1 300m³
8. Sound Level

	125Hz	250Hz	500Hz	1KHz	2KHz	4KHz
At Outlet	78dB	75dB	69dB	68dB	67dB	67dB

 Sound Output 3m from unit within NC60
9. Fuel 4.5 cSt oil @ 20°C (35 sec Red No.1) gas oil
10. Fuel Throughput $1.46 \times 10^{-3} \text{ kg/s}$ (1.4 gph)
11. Pump Pressure 7.6 bars (110 psi)
12. Nozzle Size $1.44 \times 10^{-3} \text{ kg/s}$ (1.65 us, gph) 45°
13. Oil Connection 9.53mm ($\frac{3}{8}$ in. o/d)
14. Approx. Efficiency 76%
15. Flue Gas Discharge:
 - Quantity $5.7 \times 10^{-2} \text{ m}^3 \text{ /s}$ (133 CFM)
 - Velocity 5.2 m/s (17 FPS)
 - Temp. 350°C (660°F)
 - CO₂ 11%
 - Smoke No. 0-1
16. Electricity Supply 240V, 1ph, 50Hz, 1kW
17. Motor 1kW ($\frac{5}{8}$ HP) 24 Rev/s (1,450 RPM)
18. Running Current 4A
19. Starting Current 26A
20. Fuse Size 13A
21. Cable Size 24 x 0.2mm (23 x 0.0076 in.)
22. Tank Capacity 91 litres (20 gal)
23. Weight 127 kg (280 lb) mobile, 94 kg (206 lb) fixed

Cost Complete cost was approximately £296 ex works.
Obtainable from Nu Way Benson (Heating & Drying) Ltd
Temeside Works, Ludlow, Salop, England.

Trays and phenum chamber

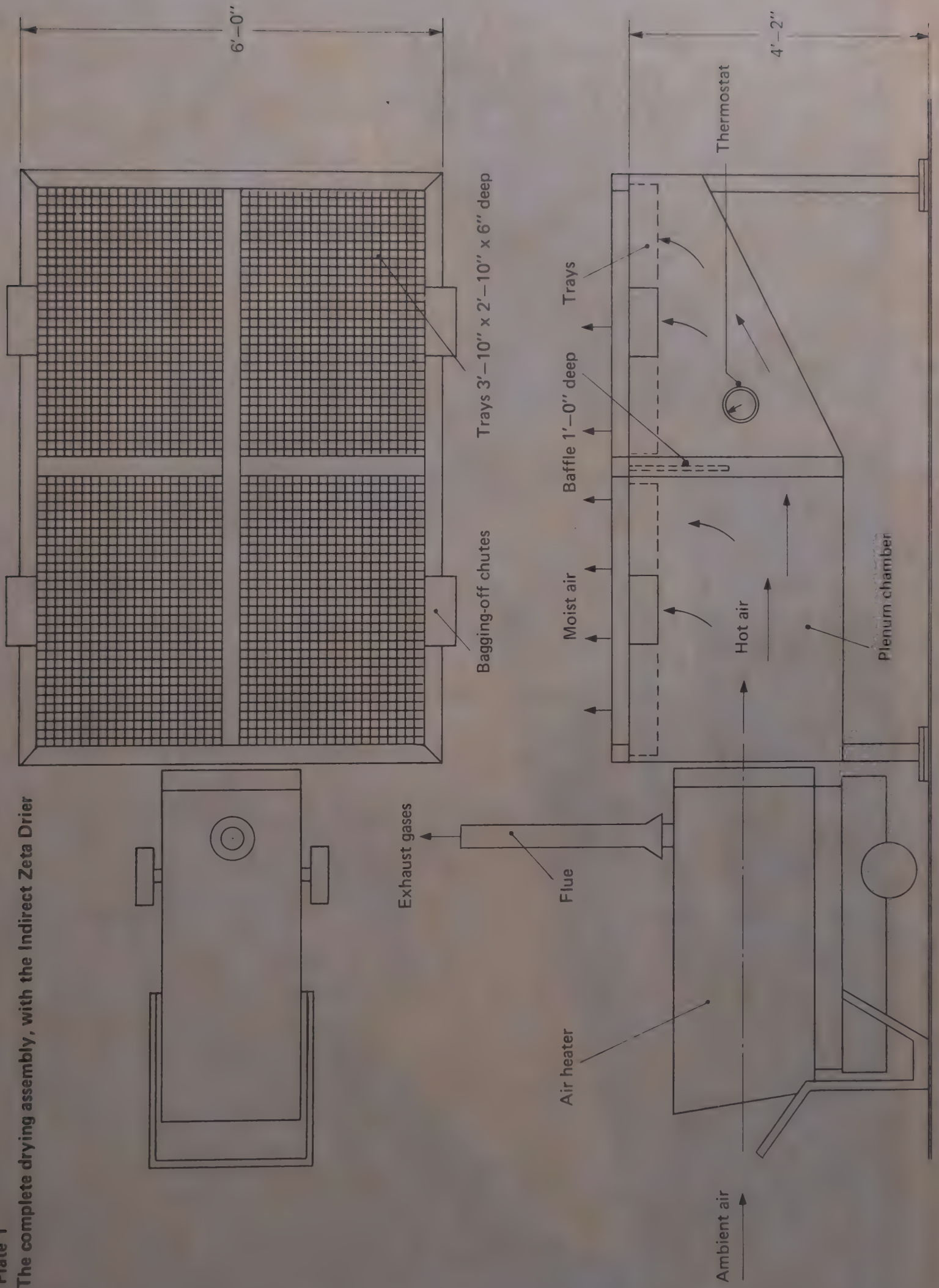
These were constructed locally of wood and the suggested scheme is shown in Figure 1.

Safety

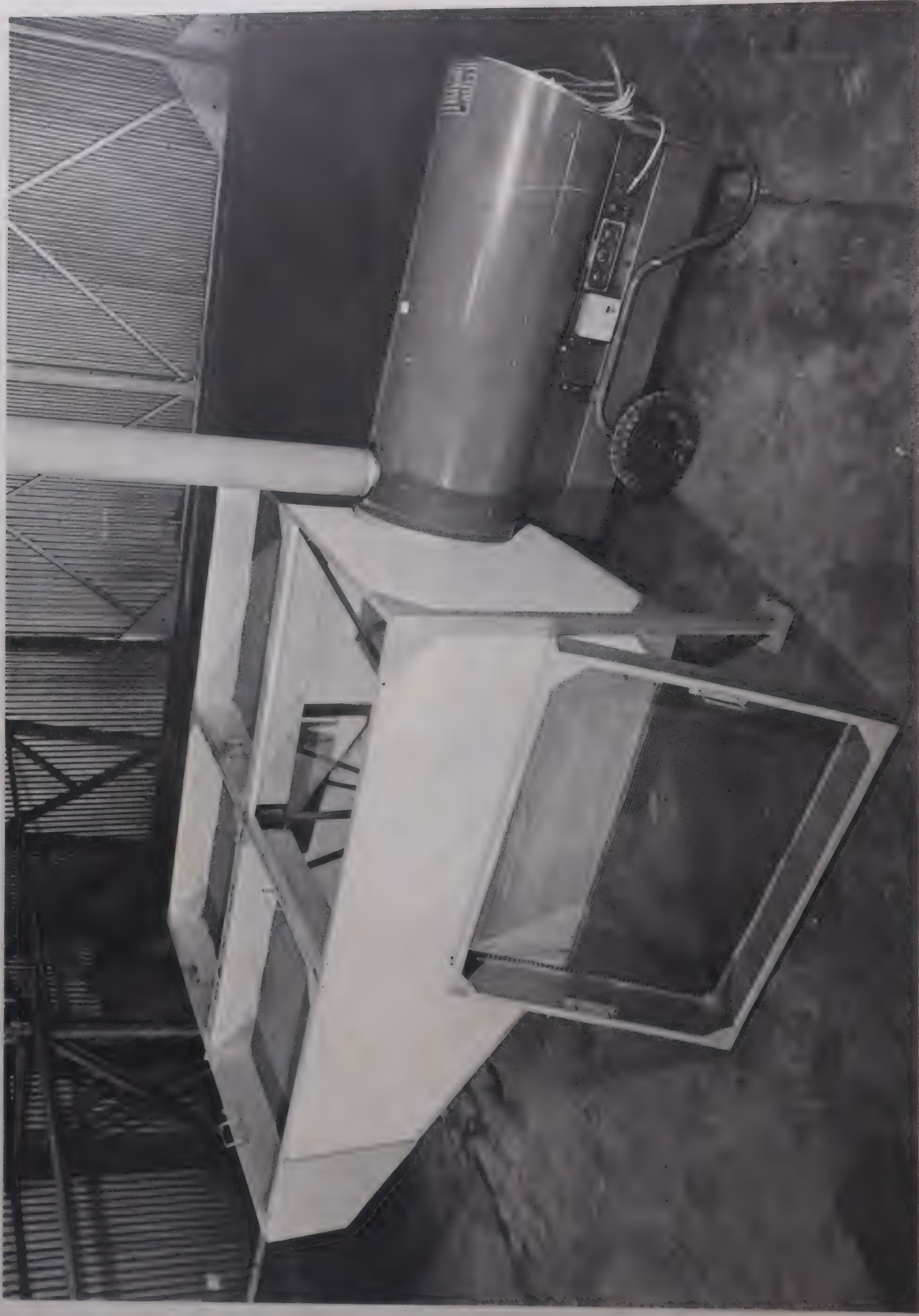
Adequate ventilation should be given to avoid build up of exhaust gases.

Plate 1

The complete drying assembly, with the Indirect Zeta Drier



The complete drying assembly, with the Indirect Zeta Drier



Description of a moisture meter for determining the moisture content of pimento berries

Moisture Meter	CERA Tester Type TCT
Supplied by	Foss Electric (UK) Ltd 75 The Mount York YO2 BP England
Price	£62
Calibration	The meter must be calibrated for pimento by means of berry samples of known moisture content (determined by the Dean & Stark entrainment method). A typical calibration (based on work carried out by P H Giles of TPI Storage Department) is given below. Alternatively, the makers might be asked to provide a special 'pimento' face-plate for the scale.

Calibration for pimento moisture content using a Cera tester type TCT

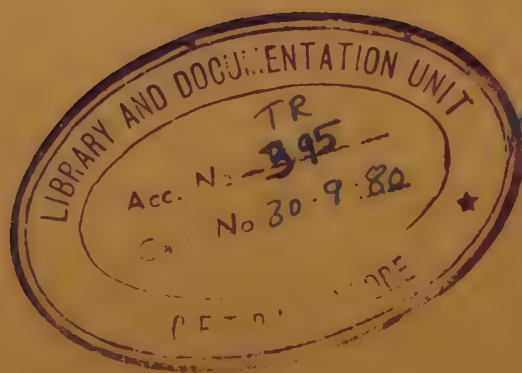
Sample size 75g
Laboratory method: Dean & Stark distillation
Cera reading: the 'Normal Scale'

Cera	M.C.	Cera	M.C.	Cera	M.C.	Cera	M.C.
0.9	10.6						
1.0	10.8	3.0	14.9	5.0	17.0	7.0	18.7
1.1	10.9	3.1	15.0	5.1	17.1	7.1	18.8
1.2	11.2	3.2	15.2	5.2	17.1	7.2	18.9
1.3	11.4	3.3	15.3	5.3	17.2	7.3	18.9
1.4	11.6	3.4	15.4	5.4	17.3	7.4	19.0
1.5	11.8	3.5	15.5	5.5	17.4	7.5	19.1
1.6	12.1	3.6	15.6	5.6	17.5	7.6	19.2
1.7	12.5	3.7	15.7	5.7	17.6	7.7	19.3
1.8	12.7	3.8	15.8	5.8	17.7	7.8	19.4
1.9	13.0	3.9	15.9	5.9	17.8	7.9	19.4
2.0	13.2	4.0	16.0	6.0	17.9	8.0	19.5
2.1	13.4	4.1	16.1	6.1	17.9	8.1	19.6
2.2	13.6	4.2	16.2	6.2	18.0	8.2	19.7
2.3	13.8	4.3	16.3	6.3	18.1	8.3	19.8
2.4	14.0	4.4	16.4	6.4	18.2	8.4	19.8
2.5	14.1	4.5	16.5	6.5	18.3	8.5	19.9
2.6	14.3	4.6	16.6	6.6	18.4	8.6	20.0
2.7	14.5	4.7	16.7	6.7	18.5	8.7	20.1
2.8	14.6	4.8	16.8	6.8	18.6	8.8	20.2
2.9	14.8	4.9	16.9	6.9	18.7	8.9	20.2

G77

**The small-scale manufacture
of high and low boiled
sweets and toffees**





Tropical Products Institute

G77

**The small-scale manufacture
of high and low boiled
sweets and toffees**

Mary N. A. Hall

May 1973

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Foreign and Commonwealth Office (Overseas Development Administration)

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Besides colleagues at the Tropical Products Institute, many individuals and organisations were asked to supply the information or advice on which this report is based and the help of all is gratefully acknowledged. Particular thanks are due to Mr F Broadbent, production manager of Pollards Confections Ltd, Newton Abbot, Devon, England, for his readiness to advise us on a variety of problems calling upon his long experience in the trade at home and overseas. A list of firms and other outside organisations which gave information used in the report is given in Appendix 3, although none of the production models represents the entire practice of any particular firm or individual, and mention of a company or product does not imply a recommendation to the exclusion of others which may be equally suitable. A list of reference books and other sources of information is also appended.

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Summaries

SUMMARY

This report is one of a series designed to help prospective investors in developing countries to assess the economic viability of various small scale industries. The manufacturing process is described and the capital and running costs involved in operating such a process are analysed. The report is intended to be applicable to a wide variety of developing countries and, although cost models are based on actual prices in West Africa and converted to sterling, sufficient detail has been included so that users in various countries who are carrying out feasibility surveys can apply their own local cost information to each physical unit and obtain relevant results.

Cost models have been worked out for three scales of output:

A, up to one ton per week, B, five tons and C, twenty tons weekly.

These require total investments in buildings, plant etc of £9,000, £54,000 and £165,000 which items include investments in working capital of £2,000, £8,000 and £28,000 respectively. It is emphasised that these investment costs are only applicable to the simplified models chosen and for prices ruling in 1970; costs are increasing due to inflation and fresh quotations should be obtained for greater accuracy. Addresses of suppliers are given in the appendix. The three scales are chosen from the range of small scale manufacture as representative of three stages in development from the traditional village cottage industry to a small establishment incorporating some labour saving machinery and supplying a limited area, and further, to one which depends largely upon semi-automatic processes and supplies a wide area. To move beyond these limits requires heavy investment in high speed fully automatic machinery and large market outlets, both of which lie outside the scope of this report. The cost information has been tabulated to show probable gross profits and returns on capital for the three scales of output.

An analysis of the models is given and variations on the working assumptions are considered and the results discussed. It has been assumed that output for all processes will be no higher than 80 per cent of the amount specified by the manufacturers in view of the probable lack of skilled labour. Distribution costs are high in developing countries and therefore a margin of 40 per cent of the retail sales price has been allowed for these in the calculation of the sales revenue. Ingredient costs represent about 50 per cent of total annual operating cost and the profitability of all three models is highly sensitive to changes in their prices. Labour costs represent a smaller percentage of total costs and increases in these have a relatively smaller adverse effect on profitability, particularly for scale C.

The common methods of manufacture have been discussed and some background explanation of boiling and cooling processes has been included where this is helpful to a general understanding of the manufacture of high boiled sweets and

toffees. Problems arising out of the effect of tropical conditions on sweet manufacture have been mentioned, in particular those concerned with air temperature and humidity control, wrapping, storage and scrap utilisation. Manufacturers and suppliers of materials and machinery stress the importance of expert advice in the choice of methods and welcome enquiries from overseas. Advice on overseas problems is also given by experts in the trade journals which should be consulted in the planning stages. A list of names and addresses is appended for sources of information.

SOMMAIRE: La fabrication des bonbons et caramels

Ce rapport qui fait partie d'une série conçue à l'intention des investisseurs éventuels dans les pays en voie de développement, a pour objet de leur permettre de déterminer la viabilité économique des diverses industries du secteur secondaire. Il comprend la description du procédé de fabrication ainsi que l'analyse des immobilisations et des frais d'exploitation que comportent l'exploitation d'un procédé de cette nature. Le rapport est destiné à être applicable à divers pays en voie de développement et, bien que les frais types cités sont basés sur les prix courants en Afrique Occidentale et convertis ensuite en livres sterling, des précisions suffisantes y ont été comprises afin de permettre aux usagers, réalisant une étude de praticabilité en de divers pays, d'appliquer à chaque élément les informations obtenues sur place concernant les frais et d'obtenir ainsi les résultats correspondants.

Les frais types de rendement sur trois échelles différentes ont été calculés:

A, jusqu'à une tonne par semaine; B, cinq tonnes et C, vingt tonnes par semaine.

Les investissements nécessaires sous forme de bâtiments, installations, etc . . . , totalisent £9 000, £54 000 et £165 000, dont £2 000, £8 000 et £28 000 de capitaux investis respectivement en fonds de roulement. Il est précisé que ces fonds nécessaires ne s'appliquent qu'aux types simplifiés qu'on a choisi et que les calculs sont basés sur les prix en vigueur en 1970; en raison de l'inflation, les prix ont augmenté et, pour plus d'exactitude dans le calcul, il serait prudent d'obtenir des tarifs plus récents. Les adresses des fournisseurs se trouvent annexées. Les trois échelles sont choisies à partir de la gamme de l'activité du secteur secondaire qui correspond à trois stades d'évolution, depuis l'artisanat traditionnel du village au petit établissement comprenant certaines machines pour alléger le travail de la main-d'oeuvre et approvisionnant une zone limitée, pour arriver enfin au secteur d'activité qui dépend, dans une large mesure, des procédés semi-automatiques et approvisionne une vaste zone. Pour s'étendre au delà de ces limites, d'importants investissements tant en machinerie à grand rendement complètement automatique qu'en l'expansion de débouchés sont nécessaires — ces deux domaines se trouvent hors de la portée de ce rapport. Le prix de revient a été représenté sous forme de tableau exprimant le bénéfice brut et la rémunération du capital probables pour chacune des trois échelles de rendement.

Le rapport comprend l'analyse des investissements types, l'évaluation des variations d'hypothèses et la discussion des résultats. On a supposé que le taux de rendement pour tous les procédés ne serait pas supérieur à 80 pour cent du taux prévu par les fabricants étant donné le manque probable de main-d'oeuvre qualifiée. Dans les pays en voie de développement les frais de distribution sont assez élevés et, pour en tenir compte, on a donc retenu, dans le calcul du produit de ventes, une marge de 40 pour cent sur le prix de vente au détail. Le prix des ingrédients représente 50 pour cent environ du montant total des frais d'exploitation annuels et, pour tous les trois types la rentabilité est très sensiblement affectée par les mouvements de ces prix. Les frais de main-d'oeuvre ne représentent qu'un faible pourcentage du prix de revient total et une augmentation de ceux-ci n'exerce qu'une faible influence défavorable sur la rentabilité, notamment sur celle de l'échelle C.

On a inclus la discussion des méthodes courantes de fabrication ainsi que certaines informations sur les procédés de cuisson et de refroidissement où ceci est nécessaire à la compréhension de la fabrication des bonbons et caramels. Les problèmes qui résultent de l'influence des conditions climatologiques sur la fabrication des bonbons se trouvent mentionnés, notamment ceux de la température et de l'humidité sur l'emballage, le stockage et l'utilisation des déchets. Les fabricants et les concessionnaires de machines et d'équipements insistent sur le fait qu'il est important d'obtenir les conseils d'un expert en ce qui concerne le choix des méthodes et ils accueillent toutes demandes de renseignements provenant de l'étranger. Les publications professionnelles qu'il faudrait consulter quand ces projets sont encore à l'étude, donnent aussi des conseils sur les problèmes auxquels on fait face dans les pays d'outre-mer. Une liste des noms et des adresses auxquels on peut s'adresser pour tous renseignements complémentaires se trouve annexée.

RESUMEN: La fabricación de caramelos y de dulces

El presente informe es parte de una serie de ellos cuyo cometido es el de orientar a los posibles inversionistas en países en fase de desarrollo, en cuanto a la factibilidad económica de diversas industrias a pequeña escala. Se detalla el proceso de fabricación y se analiza el capital y los costos de explotación que suponen un proceso tal. Se tiene la intención de que el informe sea común a una gran variedad de países en fase de desarrollo, y, aunque los modelos de costo se basen en precios que rigen en la actualidad en Africa Occidental y que se han traducido a libras esterlinas, se ofrece suficiente información para que usuarios de diversos países, que estén llevando a cabo investigaciones de factibilidad, puedan aplicar su propia información, relativa a los costos locales, a cada unidad física y obtener de tal manera resultados importantes.

Se han calculado modelos de costo para tres grados de producción: A, hasta para una tonelada por semana, B, para cinco toneladas y C, para veinte toneladas semanales.

Estos precisan inversiones totales en edificios, fábrica, etc. de £9.000, £54.000 y £165.000, en cuyos epígrafes se incluyen inversiones de capital activo de £2.000, £8.000 y £28.000 respectivamente. Se insiste en que estos costos de inversión son aplicables únicamente a los modelos simplificados elegidos y para precios que rigieron en el año 1970; nadie ignora que los costos se incrementan debido a la inflación y, por ende, para mayor exactitud, deben obtenerse nuevos presupuestos. En el apéndice se ofrecen direcciones de proveedores. Los tres ejemplos se han seleccionado de una gama de fabricantes a pequeña escala, representativa de tres fases de desarrollo a partir de la fabricación casera tradicional, hasta el establecimiento de una pequeña industria provista de cierta maquinaria que represente un ahorro de mano de obra y que suministre a una zona limitada, y aun hasta una que se base en su mayor parte en procesos semiautomáticos y cuya zona de abastecimiento sea vasta. Para traspasar estos límites, se requieren grandes inversiones en maquinaria completamente automática y de rápida producción con grandes salidas a los mercados, todo lo cual se sale ya de los límites de este informe. Las tablas de información sobre costos muestran los beneficios brutos y utilidades contra el capital para los tres grados de producción.

Se ofrece un análisis de los modelos y variaciones acerca de datos de explotación que se anticipan, discutiéndose, finalmente, los resultados. Se asume que en las tres escalas, la producción en todos los procesos de fabricación no excederá el 80% de la cantidad que especifiquen los fabricantes, en vista de la posible carencia de mano de obra experta. Los costos de distribución son altos en países en fase de desarrollo, y, por lo tanto, se ha reservado para ellos un 40% del precio de venta al detallista, al tratar de calcular las entradas por concepto de ventas. El costo de los ingredientes representa aproximadamente un 50% del costo total anual de explotación y la ganancia correspondiente a cada modelo se verá afectada por cambios en los precios de tales ingredientes. El costo relativo a la mano de obra representa un porcentaje más reducido de los costos totales y cualquier

incremento por este concepto traerá consigo un efecto adverso, relativamente menor, en cuanto a la ganancia se refiere, especialmente en el modelo C.

Igualmente, se someten a discusión los métodos de fabricación, incluyéndose ciertas explicaciones de antecedentes de los procesos de ebullición y enfriamiento cuando éstas constituyen una ayuda para el entendimiento general de la fabricación de caramelos de alta ebullición y de dulces de azúcar con leche. Los problemas que se derivan del efecto de los ambientes tropicales sobre la fabricación de caramelos también se han mencionado, en especial los que se refieren a la temperatura atmosférica y humedad y control de las mismas, envolturas, almacenamiento y utilización de residuos. Los fabricantes y proveedores de materias y de maquinaria puntualizan la importancia de obtener el consejo de expertos a la hora de decidir acerca de los métodos y prestan su mayor atención a las consultas que se les dirige desde el extranjero. En el curso de las fases iniciales de planificación, deben también consultarse las revistas del ramo en las que los expertos exponen sus puntos de vista y sus consejos acerca de problemas que surgen en el extranjero. Se adjunta una lista de nombres y direcciones de quienes se consideran como buenas fuentes informativas.

Introduction

THE PURPOSE AND SCOPE OF THE REPORT

This report is one of a series designed to help prospective investors in developing countries to assess the economic viability of various small scale industries. The manufacturing process is described and the capital and running costs involved in operating such a process are analysed. The report is intended to be applicable to a wide variety of developing countries and although cost models are based on actual prices in West Africa and converted to sterling, sufficient detail has been included so that users in various countries carrying out feasibility surveys can apply their own local cost information to each physical unit and obtain relevant results.

Sugar confectionery covers a wide range of products which present a variety of problems in their manufacture and storage. Boiled sweets and toffees were chosen since they are comparatively simple to make and relatively trouble-free in storage. The main ingredients of sugar, glucose and vegetable fat are produced in their raw state in many developing countries and there are a growing number of processing plants in these countries which are able to produce a refined product. An expert assessment of the quality of locally available supplies will be necessary in order to decide which inputs must be imported. All confectionery products require some skill in manufacture. Experienced help and knowledge of local conditions are essential for any undertaking, and it is hoped that this report may serve as a guide.

Cost models are worked out for three scales of output: up to one ton per week, five tons and twenty tons weekly. These three scales are chosen from the range of small scale manufacture as representative of three stages in development from the traditional village cottage industry to a small establishment incorporating some labour saving machinery and supplying a limited area, to one which depends largely upon semi-automatic processes and supplies a wide area. To move beyond these limits requires heavy investment in high speed fully automatic machinery and large market outlets, both of which lie outside the scope of this report.

METHOD

The operational data for the three scales of output were collected from various confectionery manufacturers and suppliers in Britain and West Africa. Estimates of capital costs were given by machinery makers and suppliers of second-hand machinery. The cost information has been tabulated to show probable gross profits and returns on capital for the three scales (see Tables 1–5, Appendix 2). The derivations of data are given in the notes to the tables, in Appendix 1. An analysis of the models is given in Chapter 3 in which variations on the working assumptions are considered and results discussed.

Some general considerations on the choice of the scale of output are outlined in Chapter 4. A product mix of five parts in weight of boiled sweets to two parts

by weight of toffee was thought to be appropriate being typical of consumer preferences in parts of West Africa. There are an infinite variety of sweet recipes to choose from and those used are representative of a standard economical boiled sweet and of a toffee suitable for use in the tropics (see Appendix 1, page 26). A general account of the manufacturing processes and conditions of storage is given in the following chapter.

Manufacture and materials

OUTLINE OF PROCESSES

High boiled sweets, such as fruit drops and rocks, are made by boiling sucrose, glucose and water together in large pans to temperatures of the order of 300°–320°F (150°–160°C). The syrup is then poured onto large cast iron tables where it cools rapidly to a pliable mass which can be handled. Colour and flavouring agents are kneaded lightly into the batch which is then shaped by hand or by machine rollers to a convenient size for passing through rotary dies which mould the sweets. After some cooling, the sweets are wrapped by machine or hand processed and packed in airtight containers.

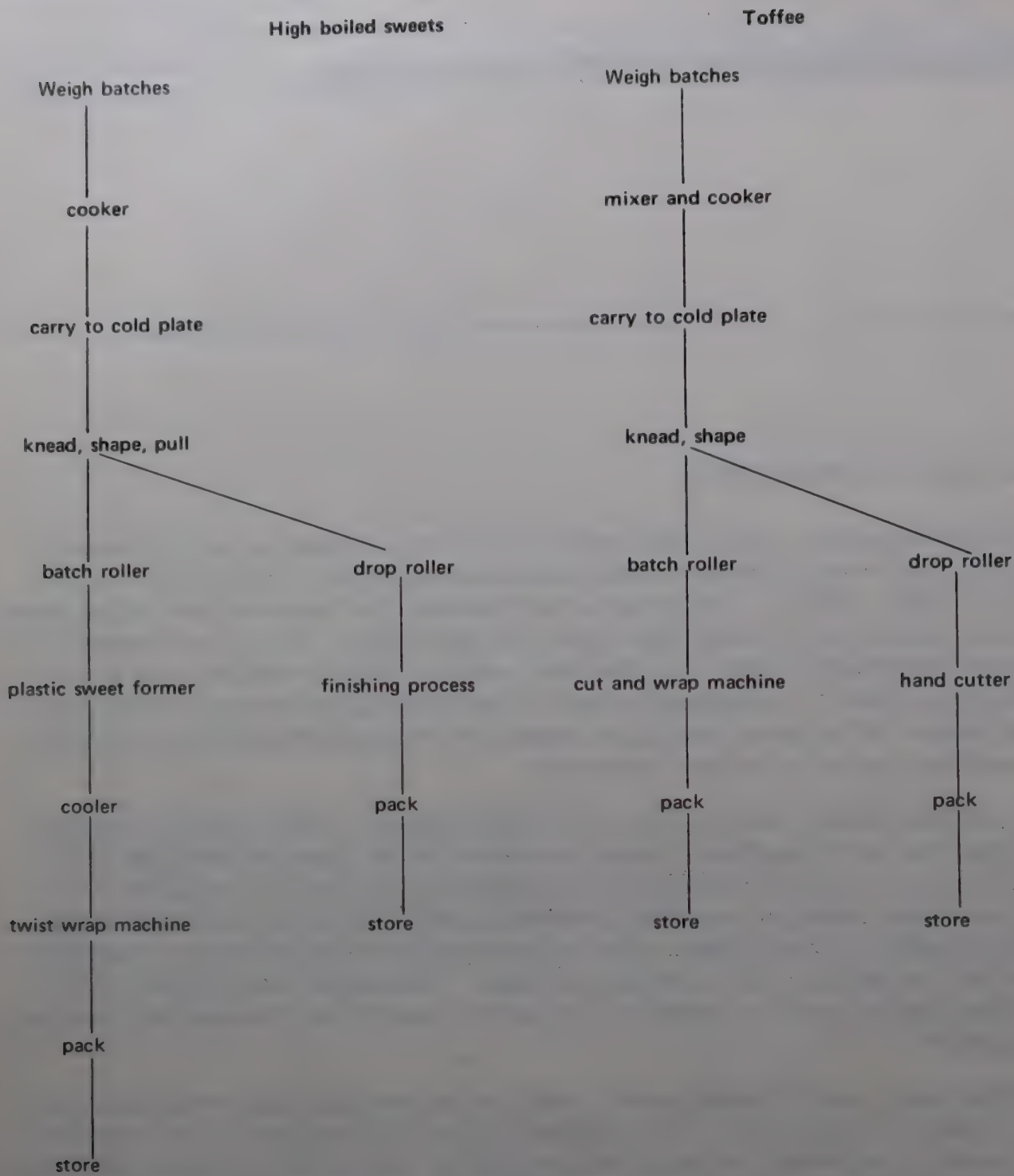
Low boiled sweets, such as creams and fudges are also made by boiling sucrose, glucose and water together in large containers but to lower temperatures, 240°–270°F (115°–132°C), often with the addition of fats and milk products. The syrup is then cooled to a certain temperature before being beaten to encourage the formation of fine crystals, when it is poured into a frame set on a cold table and left to continue the crystallising process. This cooled mass sets to a finely grained creamy product, which can be cut into squares and has excellent keeping properties.

Toffees are a type of boiled sweet made from sucrose, glucose, water, fats, milk and emulsifying products. The ingredients are mixed together in the container for some time before cooking to ensure that the fats, solids and liquids are evenly distributed throughout the mass, or emulsified. When milk is heated with sugar, it partially decomposes or caramelises to give the characteristic flavour of caramels and toffees. The fat tends to separate out during the cooking period and so an emulsifying agent is added to prevent this: suitable agents are milk, gelatin and lecithin, often in the form of powdered soya product. The emulsified ingredients are then heated in the container and continuously stirred until a temperature between 260°–280°F (126°–138°C) is reached when the boiling syrup is poured out onto long cast iron tables to cool. Crystallisation of the toffee is inhibited by the high proportion of glucose syrup in the mix, about a third the weight of raw materials used. The soft toffee can be cut by hand into blocks for subsequent hand wrapping or it may be shaped in a heated batch roller and fed into a machine which cuts it and wraps the pieces ready for packing.

EXPLANATION OF BOILING AND COOLING PROCESSES

High boiled sweets, sometimes known as high boilings or hard boiled sweets, are concentrated solutions of sucrose which have been cooled to form a transparent solid containing less than 2 per cent moisture. Under normal conditions, the sucrose would crystallize to form an opaque sugar mass with a rough crystalline texture, but this can be prevented by the addition of invert sugar or glucose syrup. Both of these contain dextrose which inhibits the crystallization of sucrose by being absorbed on the newly formed crystal surfaces and protecting it from further

WORK-FLOW CHART



growth. The addition of dextrose to prevent crystallization is called 'doctoring' and is an essential part of the production of boiled sweets. Most of the difficulties encountered in manufacture are concerned with adjusting conditions so that crystallization is avoided or controlled so that a smooth or fine-grained product is obtained. When sucrose is boiled in the presence of acids, such as citric, tartaric or malic acids, some of the sucrose is broken down to invert sugar which will then affect the crystallization point of the solution by the doctoring action of the newly-formed dextrose. The results of acid boiling are extremely variable and difficult to control and so this method of doctoring has been supplanted by the use of glucose syrup which is a reliable and tolerant agent. Glucose syrup has the additional advantages over invert sugar of reducing breakage of the sweet, increasing its chewiness and slow-dissolving properties and lessening its tendency to absorb moisture from the atmosphere. Glucose syrup is made by the conversion of starch into dextrose and certain other sugars. Crystalline dextrose is sometimes called glucose when used medicinally, but this report follows the confectionery industry in the use of the term glucose as referring to the syrup.

Sucrose and glucose syrup are used in the proportions by weight of 70:30 for open pan cooking and 60:40 for vacuum cooking. When the ingredients have been measured into the cooking vessel together with sufficient water to dissolve the sugar completely, the mixture is heated strongly until it boils. Great care is

taken to see that there are no undissolved crystals of sugar left in the vessel which would encourage unwanted crystallization later on in the process. The boiling point rises as water is driven off and the sugar solution becomes more concentrated. For each type of sweet, the temperature reached in the boiling process is very important since it defines the amount of water left in the syrup and thus the texture that the final product can develop. One degree variation in final boiling temperature can make the difference between a sticky, cloudy sweet and a clear, dry one. The order of addition of ingredients given in the recipe must be strictly adhered to, since each contributes towards a specific action on the boiling. For this reason, acid used to enhance fruit flavours is usually added at the end of the cooking time to prevent inversion of the sucrose which would vary the texture and keeping qualities of the product. Colouring and flavouring agents can be affected by high temperature and are therefore added when the syrup is cooling.

TYPES OF COOKERS

There is a variety of methods of boiling syrup and the simplest use open pans of copper, stainless steel or aluminium. Open stoves burning solid fuel, gas or oil are used for cooking and the pans are set in large openings on top of the stoves. The boiling syrup may be stirred by hand with a wooden spatula but mechanical stirrers are necessary for larger quantities. These stirrers must be capable of two speeds for toffee manufacture, the slow speed for the pre-cooking emulsifying action and the fast speed during the heating period to prevent burning and to maintain the emulsion.

Steam jacketed pans provide a uniformly distributed source of heat for boiling low temperature sugar syrups. These pans have an outer jacket welded on to the inner lining, leaving a gap through which steam under low pressure (60–100 psi) can be passed. If a supply of steam is not available self-generating steam pans may be obtained, in which the steam is made in a gas heated pressure jacket surrounding the cooking pan. High pressure steam (150 psi) must be used to obtain the temperatures required by high boilings. The syrup is heated by a coil through which steam at high pressure is passed. The steam required for all manufacturing purposes in models B and C of this report is supplied by oil-fired boilers.

When a boiling sugar solution is held under vacuum, the water content of the syrup is rapidly reduced without raising the temperature and this fact is used in vacuum cooking to overcome some of the problems associated with the high temperatures and long boiling times in sweet manufacture. Batch vacuum cookers are recommended for use in the manufacture of both high boiled sweets and toffees. The ingredients are heated in a pre-melting pan to a temperature just below that at which spoilage might take place. The pan is connected to the vacuum cooker and when the required temperature is reached, the connecting valve is slowly opened allowing the boiling syrup to enter the vacuum chamber in a fine spray. The vacuum applied to the syrup reduces the water content to a satisfactory level: the cooker is then allowed to return to atmospheric pressure and the syrup is drawn off for processing. The plant is then ready to receive a new batch of ingredients for boiling and reducing under vacuum.

Continuous cookers are completely automatic machines which are fed from hoppers containing the ingredients; using steam heat and electric power, they produce a continuous flow of cooked sugar syrup in quantities from a ton an hour upwards. The cookers are connected in series with machines which can process the syrup automatically right through to the stage of packaging the final sweet product. The large investment involved in equipping a factory with these automatic lines of manufacture renders them suitable only for outputs well in excess of forty tons a week, and so they are outside the scope of this report.

FORMING THE SWEET

When the syrup has reached the correct temperature and water content, it is poured out of the cooking vessel onto a cold table to cool. In open pan cooking, small batches can be carried by hand to the tables, but in all other cases arrangements must be made to tap off the syrup into receiving pans which can be carried by hand or trolley to the tables.

High boiled sweets can have a variety of finished appearances according to the degree of clarity of the sugar mass. Great care has to be exercised in the handling of the plastic sugar to prevent crystallization if clear drops are being made. The simplest method of making drops is to feed a long strip of plastic sugar through a pair of drop rollers, the dies of which combined to mould the sweet, then part to allow it to drop out as the rollers turn. The numbers of sweets formed at a time depend on the width of the rollers and the number of moulds engraved on them. The rollers can be hand or power operated and are available in a wide variety of designs, which are readily interchangeable.

A greater output of formed sweets is obtained by the use of a series of machines which are linked together: a batch roller, rope former, sizer and sweet moulder. The batch roller contains a set of revolving cone-shaped heated rollers on which a batch of plastic sugar is placed to shape it into a long roll while the end is being drawn out through the rope former and sizer. It emerges as a continuous rope which is fed into the rotating dies of the moulder which form the sweets. These are ejected onto the moving belts which carry them away to cool.

Some sweet finishes require the sugar mass to be aerated so that fine crystals form, giving it a satin sheen: for this purpose the batch is laid over the arms of a rotating sugar pulling machine and the loop formed is stretched and folded automatically until the required texture is obtained. If the sweets are to be filled, the filling is prepared separately and may then be enclosed within the sweet covering by hand folding followed by shaping into a rope on a heated batch roller: rocks and filled satins are made in this manner. Large quantities of filling may be handled by using a batch centre filler which feeds the filling continuously into the centre of the batch while it is being shaped in the batch roller.

Low boiled sweets and toffees can be made using variations on the methods outlined for manufacturing high boiled sweets. The simplest method of forming toffee is to pour it into a rectangular shape on a cold table and when cool to cut it by hand or machine into squares or bars for subsequent wrapping. Toffees are also formed by feeding a bar of plastic toffee through a drop roller machine which cuts it into continuous narrow strips which may then be cut into small pieces with a hand operated rotary caramel cutter. For higher outputs, the toffee is handled mechanically on a linked series of batch roller, rope former and sizer followed by a cut and wrap machine which delivers the wrapped toffee at speeds of 300 or more pieces a minute.

FINISHING PROCESSES, WRAPPING AND PACKAGING

After the sweets are shaped, they are cooled somewhat before further finishing or wrapping. In the simplest method, sweets made on a drop roller may be dusted lightly with confectioner's flour and left to cool on open tables in a draught of air blown over them by a fan. The cooled sweets are shaken in a sieve to remove connecting links of sugar and then may be packed in polythene bags or jars in weighed quantities. High boiled sweets can be given a sugar coating which renders them very resistant to moist conditions. They are turned in a slowly rotating pan together with sufficient syrup to coat them, then fine sugar is added to cover the surfaces and they are taken out to cool and pack.

When sweets are being produced continuously from lines of automatic machines they are usually carried away from the forming machines on conveyor belts in a cooling draught of air, which is designed to reduce their temperature to about 95° F (35°C) when they are ready for wrapping. Sweets are delivered in a chute to the wrapping machine where a strip of waxed paper, foil or cellulose film is cut and wrapped around the individual sweet which is sealed by twisting or crimping the ends of the wrapping strip. An infra-red lamp is fitted over the cutting and wrapping surfaces to help protect the sweets from adverse damp conditions which can cause stickiness. Wrapped sweets are ejected from the machine at rates between 160 and 500 pieces a minute and are conveyed to the packing area to be packed into suitable containers ready for storage and delivery to the retailers. Large screw topped glass jars are widely used to store sweets in, but these present problems in collecting and washing the jars for re-use, problems which can be eliminated by the use of thick polythene bags with simple wire twist closures. If bottles are used, up to 1000 a week can be washed by hand; for larger numbers a small washing tank is necessary until quantities of over 5000 a week are being handled, when a bottle washing machine becomes economic.

AIR TEMPERATURE AND HUMIDITY CONTROL

The ideal air conditions for cooling high and low boiled sweets are for a temperature of 68° F (20°C) and a relative humidity of 45 per cent. Toffees contain a higher percentage of moisture and so will withstand relative humidities of 55—75 per cent at this temperature. In these conditions, the product will have a negligible tendency either to take up or to lose moisture and so it remains in a stable condition. These ideal conditions should be borne in mind when considering arrangements for handling the sweets after they have been formed and before they are protected by individual or bulk wrapping. Sweets are formed in moulds while they are still warm and plastic: they have little tendency to absorb water when they are at a temperature above that of their surroundings and therefore it is desirable to wrap sweets as soon as possible after forming. This is easily arranged when automatic wrapping machines are incorporated in the manufacturing line but it is not always possible when there are further finishing processes to be done before hand weighing and bulk packing. It is usual for the forming and wrapping rooms to be controlled in temperature and humidity: this can be done economically without full air conditioning if the relevant areas requiring control are separated from sources of heat and steam and from areas which do not require control. The cooking area should have an extraction fan and air circulating system but requires no special conditions. The cooling area is obviously better separated from the cooking area but it is vital that the sweet forming area should be free from steam so that the moulded sweets can cool in conditions approaching ideal.

The humidity of a small room can be reduced quite inexpensively by installing a dehumidifier which removes moisture from the surrounding air. The temperature and humidity of a room can be lowered by installing a simple cooling device in the external wall: the air entering the room is cooled by a refrigerating coil which also condenses some of the moisture from the warm air. The cool dried air is blown into the room and warm air extracted. The number of cooling units required depends on the volume of the room and the particular air conditions of the surroundings: advice must be sought from manufacturers who specialise in air conditioning. Full air conditioning is an extremely costly investment and requires quite extensive arrangements in the building to ventilate and isolate the various areas requiring conditioning, quite apart from the cost of the actual air conditioning plant. This would only be undertaken for a much larger scale of manufacture than is being considered here.

WRAPPING MATERIALS AND CONTAINERS

Wrapping materials should protect the sweet from moisture and keep the product clean during subsequent handling. The most appropriate containers are strong

plastic bags large enough to hold five pounds of sweets and closed with a wire twist. These can be packed in cardboard cartons for storage and transport. Plastic bags are readily available in most parts of the world and may be bought ready made or in continuous tube form, when a simple end-sealing machine is used to make up the bags as required. The traditional large screw topped sweet jar has many disadvantages in use in developing countries. The jars are expensive to obtain, must be ordered in very great bulk to obtain a reasonable price, often a year's supply in advance for remoter areas, which presents great storage problems. They must be returnable and must be washed before use. The transport of large glass containers is cumbersome and breakage risk is high. In recent years, there has been an increased use of small sealed plastic bags which are filled and sealed automatically, are easy to handle, attractive to display and may be sold direct to the customer in ¼lb and ½lb units. Plastic bags do not require any special storage conditions. The reels of film for machine wrapping must be of a reliable and consistent quality and will usually be imported. Cellulose film is recommended since it can withstand wider variations in storage conditions than waxed paper. It should be stored in the area where temperature and humidity are controlled, probably this will be the wrapping room itself. This precaution is to ensure that the film works smoothly in the wrapping process. It has no special storage requirements when wrapped around the sweets.

STORAGE OF SWEETS

When properly wrapped and contained in relatively airtight jars, bags or boxes, the storage of high and low boiled sweets presents few problems: it is not necessary to condition the air during storage. The containers are usually stored on open shelving in a well ventilated warehouse with an easy access to the loading bays for delivery trucks. The amount stored will be in relation to the rate at which particular varieties are produced compared with the size of the orders for them and may average the factory's total output for one month. When the storage of raw materials is also taken into account, it will be realised that warehouse space is a major consideration in the planning of a smoothly flowing production line.

QUALITY CONTROL AND ROUTINE MAINTENANCE

Quality control in the manufacture of high boiled sweets and toffees is maintained by rigid formulation of the recipes and exact processing methods. Workers involved in production must be trained to work to exact instructions. A process sheet containing every detail of his job should be given to the individual worker, including references to safety hazards or points requiring special precautions. Exact process methods and well trained workers should result in a product of the required standard. Laboratory testing is not considered necessary for these scales of production.

Absolute cleanliness is essential in every stage of food manufacture to prevent the growth of mould or bacteria particularly in conditions of high temperature and humidity. It is recommended that production workers be responsible for the cleaning operations of their own machines and working areas to ensure their involvement in good standards of hygiene. Fifteen minutes a day is sufficient for the routine cleaning of boiling pans, work surfaces, tools and for floor-sweeping. Excessive moisture is undesirable except in the boiling rooms so floors should be washed only at the end of the week's work. One hour a week is sufficient for the routine cleaning of machinery and floor washing. A monthly routine for washing part of the walls and surrounding areas ensures that the factory is systematically cleaned throughout the year.

SCRAP UTILISATION

There will always be a proportion of waste product in the manufacture of sweets in addition to the malformed and badly wrapped ones which are unsuitable for sale. The moulded shapes are formed in continuous strips and the connecting links must be removed by trimming and sieving. A well designed programme for scrap utilisation is essential since discarded waste is discarded profit. All waste products should be re-cycled whenever possible. Scrap from high boiled sweets may have crystallized and therefore should not be added directly to fresh boilings because of the danger of inducing further unwanted crystal formation. Suitable scrap may be completely dissolved in the minimum quantity of water and a measured proportion incorporated into the formulation of a new batch of the same type. The remaining scrap which by reason of colour or acidity is unsuitable for use in this way, can be used to make a low temperature boiling which is suitable as a filling for high boiled sweets.

RAW MATERIALS

Sugar

There are several grades of refined white sugar or sucrose, differing in the amount and type of minute quantities of impurities present. A particular grade may be excellently suited for one type of sugar confection but quite unsuitable for another. Lower grade sugar may be contaminated with strands of sacking and foreign particles and may need sieving before use. A sugar chemist should be asked to advise on the grade of sugar suitable for the intended range of products. Sugar can be delivered in bulk by tanker and pumped into hoppers for storage or it may be delivered in smaller quantities in hundredweight sacks. There are no unusual storage problems. It is possible to buy a blended sucrose and glucose syrup but this is only suitable for the large throughput of automatic production lines.

Glucose syrup

This clear viscous liquid may be delivered in bulk by tanker and pumped into storage tanks or it may be delivered in drums. The syrup must be kept at a steady temperature, and in cold climates a small heating coil is incorporated in the glucose tank to keep the syrup free-flowing. On the other hand too much heat in storage causes the syrup to develop a brown colour which may spoil the product.

Glucose syrup is classified according to its dextrose or reducing sugar content, measured by dextrose equivalent, DE, with ratings given according to strength thus:

low conversion glucose	28–37 DE
regular conversion glucose	38–47 DE
intermediate conversion glucose	48–57 DE
high conversion glucose	58–68 DE

Under normal conditions of climate, the regular conversion glucose 40–43 DE is used; however, for very humid conditions, low conversion glucose, 34 DE, is recommended for the manufacture of a sweet more resistant to moisture. In recent years, it has been shown that sweets made with glucose containing a high proportion of maltose (high maltose 42 DE) have five times the shelf life of those made with normal glucose, due to their reduced tendency to attract moisture from the atmosphere. In spite of these considerations, there may be no choice of glucose available, and the recipe must be adapted in other ways to take account of the climate

Water

It is extremely important that the water used in sugar boiling has known characteristics of acidity or alkalinity and mineral content, since these influence the rate of inversion during boiling, the flavour and the colour of the product. Ideally the water should have a neutral reaction, being neither acid nor alkaline. This can be obtained by testing the water initially and using a simple corrective to bring it back to a neutral state.

Confectionery fats

A range of vegetable fats are available and those made from hydrogenated palm kernel oil are recommended as being stable under extreme conditions of heat and high humidity. This can be obtained as a hard, white fat with a melting point of around 100°F (38°C) giving a toffee which keeps its shape well in storage and has a good chewiness when eaten. The fat must be stored in a well-ventilated place away from the light, at a temperature of at least five degrees fahrenheit (three degrees centigrade) below its melting point.

Emulsifying agents

Those in common use in the manufacture of toffee are soya, lecithin and glyceryl monostearate, GMS. They are used in very small quantities, proportionate to the amount of fat required to be emulsified, and will probably be imported.

Milk products

Sweetened condensed milk, full cream or skimmed, is a common ingredient of toffee and grained fudge giving it a creamy flavour. It is stored in air-tight containers and requires temperatures below 60°F (16°C) for long storage.

Dried skim milk powder can be used as a substitute for condensed milk, being widely available and easy to store. It is reconstituted in batches and boiled with sugar and glucose to make a product identical to commercial skimmed condensed milk. The reconstituted milk must not be stored since it is liable to rapid deterioration by bacterial action. Very careful cleansing of all utensils is necessary to keep them free from infection and mould.

Acids

Citric, tartaric and malic acids are those most generally used in sweet manufacture, usually to enhance the added fruit flavours. Granulated acids are preferred to the powdered form because they are easier to distribute in the sugar mass.

Flavouring agents

Essential oils are natural products which give a distinctive flavour to foodstuffs, but they are expensive and are usually replaced by synthetic flavours. The manufacturer of synthetic flavours will need to know the type of sweets intended and conditions of their manufacture before he can advise on suitable flavours and methods for their use. Some developing countries will need to import flavouring and colouring agents and a considerable saving in cost can be made by bulk buying. The small manufacturer must expect to store flavouring agents for several months under cool dark conditions.

Colouring agents

These have to be chosen from a list of permitted confectionery colours for the country concerned. They can be obtained as powders which have to be made up to an accurate solution in water and added to the batch in small measured quantities. Colour sticks are made in which a fixed percentage of colour is held in a gelatine base and the whole stick is added to the batch of sugar; this eliminates the likelihood of error in weighing and the disadvantage of adding water to a boiled batch. The same considerations of bulk buying apply here as for flavouring agents.

Analysis of models

HOW TO USE THE MODELS

The cost tables in Appendix 2 set out cost models for the sweet manufacturing process and illustrate the use of cost information to obtain conclusions on the viability of schemes for investment. All tables are given for the three scales of output, models A, B and C (50 tons, 250 tons and 1,000 tons per annum respectively). The main conclusions may be drawn from Table 1 which summarises the total investments, operating costs and returns from the project. The remaining tables show, in detail, the information from which Table 1 is calculated. The tables should be studied together with the notes in Appendix 1 which give a row by row interpretation of any derivations that are not obvious. Tables 3, 4 and 5 detail the type and cost of machinery and equipment for the three models. Tables 6 and 7 detail the quantities and costs of the inputs. Table 8 summarises the labour requirements and wage costs. Table 2 shows the steps involved in calculating rates of return when initial and annual tax allowances are taken into account. This table also summarises the rates of return obtained on the assumption that second hand machinery is used where appropriate. It is hoped that the reader will be able to use the model outline in the eight tables as a basis for costing exercises, using information on local costs and current quotations for machinery prices which may be affected by inflation.

In order to provide a realistic framework, the models have been calculated against a background of costs for West Africa, using simplifying assumptions in order that the general method may remain clear. The sales revenue has been estimated from the current 1971 average retail price for boiled sweets and toffees in West Africa. Distribution costs are very high in developing countries and therefore a margin of 40 per cent of the retail sales price has been allowed for these in the calculation of the sales revenue. The probability that most of the workers involved in the manufacturing process will be unfamiliar with factory methods will tend to result in a relatively low efficiency of output. Therefore throughout the calculations, it has been assumed that output will be at a level of 80 per cent of the amount specified by the manufacturers.

There are several ways of assessing the viability of an investment in a business venture and some of these are discussed in this chapter. The answers obtained vary according to the way in which profit and invested capital are defined, particularly with regard to depreciation and taxation. The basic assumptions of market demand and type of product desired should be carefully examined before using any model as it stands. Sufficient detail has been included to suggest ways in which they may be modified. Some aspects of the choice of scale are considered in Chapter 4.

RATE OF RETURN ON CAPITAL

This method of assessing profitability compares the amount of annual profits with the total investment. The formula used to calculate rate of return is:

Rate of return on capital = Profit expressed as percentage of total investment.
Rates of return have been calculated in two different ways in Table 1, Appendix 2: the first (row 26) was calculated using a figure for gross profit obtained after allowance had been made for depreciation but before tax: the second rate of return (row 27) was calculated using a figure for gross profit obtained after all adjustments for tax and depreciation had been made. The effect of tax and tax free allowances on both profit and total investment is such as to reduce the rate of return by about a third and demonstrates the importance of their inclusion in an estimation of profitability.

Table (a) below shows the effect on rates of return if certain of the factors concerned are varied.

Table (a)
Variations in rate return on capital including depreciation before tax

	Scale A	Scale B percentages	Scale C
Rate of return from Table 1 row 26	41	50	74
Rate of return if:			
ingredients costs doubled	-20	2	12
supplies costs doubled	36	39	56
labour costs doubled	-11	36	59
output halved	-16	9	24
addition of one toffee cut-and-wrap machine with ancillary equipment	n.a.	28	64
second hand machinery used (data from Table 3)	50	84	90

The changes in rates of return given in Table (a) show clearly that the profitability of the three scales A, B and C are affected quite differently according to which cost is being altered. Profits of all three scales are lessened by doubling the costs of ingredients; scale A shows a loss and scales B and C show negligible profits. Halving the output causes a similar effect with scale A showing a loss, scale B a negligible profit and scale C a very reduced profit. If labour costs are doubled, scale A shows a loss but scales B and C are less affected and can still show a profit.

These results are better understood if the cost structure of the three models is examined. Table (b) which clarifies this structure, shows the variable costs taken from Table 1, rows 8–17, Appendix 2, expressed as percentages of the annual operating costs. It also shows the effect on these percentages of increasing particular costs.

With a knowledge of the percentage cost structure of the models, the variation in effect upon rates of return by increasing costs is better understood: increasing those costs which initially form a large percentage of total costs, will increase costs and decrease profits to a greater extent than will those which initially form a small percentage of total costs.

The cost of adding one toffee cut-and-wrap machine with appropriate adjustment to ancillary equipment, has been calculated. Scale A has too small an output to warrant the use of a machine, but a machine could replace the drop roller for the manufacture of toffee in both scales B and C, giving the advantage of a higher quality wrapped product. Since it would not be fully utilised in scale B and the resulting 28 per cent rate of return on capital is comparatively low, the purchase of a cut-and-wrap machine for scale B would only be justified as part of an

Table (b)

Variable costs as percentages of total annual operating costs

Costs from Table 1, Appendix 2	Scale A	Scale B	Scale C
Ingredients:			
(a) basic cost row 8	42	50	54
(b) doubled cost row 8	57	65	67
Supplies:			
(a) basic cost row 9	3	11	15
(b) doubled cost row 9	6	20	26
Power and fuel row 10	3	6	4
Labour:			
(a) basic cost row 11	35	15	12
(b) doubled cost row 11	51	26	21
Transport row 12	3	1	1
Other rows 13–16	14	17	14
Total annual operating costs row 17	100	100	100
Working capital row 7	16	16	16
Excise duty row 18	10	12	13

expansion programme. Scale C with its larger output appears able to absorb the extra costs and shows a lowered but adequate rate of return, 64 per cent. Table (a) shows the higher rates of return obtained when suitable second hand machinery is installed wherever possible. This will give no saving in running costs and there may be a greater chance of breakdown and obsolescence. These factors should be weighed against the short term advantage of a lower capital investment in used machinery.

CAPITAL RECOVERY PERIOD

The profitability of an investment may be roughly estimated by calculating the time taken to recoup the investment from annual profits, assuming all allowances have been made for tax and depreciation.

$$\text{Capital recovery period} = \frac{\text{Total investment}}{\text{net profit}}$$

All three models show a recovery period of three years or less for the basic conditions of cost and output, see Table 2, row 12, Appendix 2. This represents an acceptable return for loans advanced on the purchase of machinery. Total investment can be reduced by the purchase of second hand machinery leading to economies in the recovery period of about half a year for each model, see Table 2, row 12.

PROFIT MARGIN

A profit margin defines the limits within which costs and revenue can move relative to each other and still allow a profit to be made. It can be defined as the extent to which costs can rise until they are just equal to revenue, or the extent by which revenue can fall until it just covers costs. In both these extreme cases there are no profits. Table (c) below shows the profit margins for the three models which are calculated from Table 1, Appendix 2. The margin is equated with the profit, row 25, and is expressed either as a percentage of total costs, row 22, or of sales revenue, row 23. Consideration of the profit margin available for a given set of conditions gives some idea of how resilient a project would be in adverse circumstances in the future.

Table (c) also shows the extent to which individual costs can rise until costs are just balanced by revenue. Beyond this point a loss would be made. The models

Table (c)
Limits of cost and revenue changes to maintain profitability

	Scale A	Scale B	Scale C
	Change as percentage of original		
Profit margins:			
(a) limit of rise in total costs	+ 27	+ 49	+ 59
(b) limit of fall in sales revenue	- 21	- 33	- 37
Limits of rise in individual costs for			
(a) ingredients	+ 67	+ 105	+ 119
(b) supplies	+ 930	+ 463	+ 415
(c) labour	+ 79	+ 349	+ 549

are all sensitive to rises in ingredient costs and losses would be made in each case if the prices rose by a little more than 100 per cent. The models are less sensitive to labour costs and only A would result in a loss if costs rose by 80 per cent. Supplies represent a small proportion of total costs and the models can absorb considerable increases in these costs without unduly affecting the profits.

DISCOUNTED CASH FLOW

The calculation of rates of return on capital can give misleading results when there are several alternative investments to be considered or where there is likely to be a variation in outlay or income in different years in the life of the investment. For these purposes the technique of discounted cash flow is used. In this method, the difference between the cash inflows and outflows over the life of the project is calculated and each is discounted by an appropriate rate and totalled to arrive at the net present value. The appropriate rate is that which represents an acceptable return on capital in the business market. If the net present value is positive the investment is viable and a comparison between alternative investments can be made to find the best value. The technique has not been used in this analysis since there are not alternative investments to compare and the models show good returns by conventional methods.

ECONOMIES OF SCALE

When the output of a firm is increased by the use of a larger plant, the cost of producing each unit of output usually falls. These economies of scale are demonstrated in the three models and some aspects are shown in Table (d) below:

Table (d)
Aspects of economies of scale

	£ sterling 1970		
	Scale A	Scale B	Scale C
Unit cost per lb product from Table 1, row 17	£0.099	£0.081	£0.076
Capital invested per head of total work force, rounded to £'000 . . .	£1,000	£3,000	£3,000
Direct labour per ton of product per week	5	3	2.75

The cost of producing one pound of sweets decreases as the scale of production increases from A through B to C. This is because the costs of machinery, manpower and other overheads do not increase proportionately with the increase in output. More capital per head of work force is invested in automatic production methods as the scale of production increases, leading to a decrease in the ratio of direct labour to output. The ratio of labour to output per ton per week is reduced from five in scale A where all processes are hand operated to below three

in scale C where most processes are semi-automatic. The availability of economies of scale will depend to some extent on the relative costs of machinery and labour so local wage rates will exert a powerful influence on the choice of machinery and output. In Britain where wage rates are high, a labour : output ratio of 2 : 1 is considered ideal for small to medium scale sweet manufacture. This cannot be attained unless machines are used for forming and wrapping all sweets and this is further discussed in Chapter 4.

The improvement in quality of sweets due to greater automation of forming and wrapping in scales B and C should command a higher price than the handmade unwrapped sweets of scale A but in this report the costs have been calculated using only one average sales price.

Choice of scale

The first step to be taken when considering investment in a manufacturing process, is to estimate the size of the market open to the product so that production can take place at an appropriate scale. The market for sweets, chocolates and toffees is being increasingly taken over by a few international firms who can afford to install the most sophisticated automatic machinery making sweets at ten times the speed of traditional methods, in a continuous process, with raw materials fed in at one end of the line and wrapped, packaged sweets emerging at the other. These products of automatic lines are of a uniformly high standard and backed up by extensive marketing represent a serious challenge to any small aspiring competitor. The investor must try to take advantage of his regional knowledge of local preferences, his personal contact with local outlets and his ability to provide a wide variety of sweets not able to be mass-produced. The economic price at which the manufacturer can sell a product and the acceptable price at which the local consumer will buy the product, are the two important factors which must be equated if a business is to be profitable. The acceptable buying price can be found by careful investigation of the income levels and buying habits of the local consumers. One of the purposes of this report is to enable a potential investor to estimate the economic selling price and several methods of estimation are discussed in Chapter 3.

When the market for sugar confectionery in a developing area has been assessed and judged adequate for the establishment of a small business, it is suggested that production should initially be limited to that quantity which one sugar boiler and an unskilled assistant could make on their own, using an open fire and a few boiling pans: somewhere between five hundredweights to one ton a week, depending on the size of the market outlets. They should aim to reach break-even point on their investment in plant and buildings in the shortest possible time, before considering any expansion. For this output, an expert in confectionery production recommends that not more than twelve variations in colour, taste or texture should be attempted. Sufficient variety could be found among the simpler types of high and low boiled sweets. This small-scale venture should be used to obtain the skill and experience in local conditions necessary for an expanding business.

By the time that output has been raised to one ton a day, it would be expected that a small manufacturer would be equipped with labour-saving plant at all stages of manufacture as in Model A, although the product might be hand-fed at each stage. To reach outputs of four tons a day, while still keeping labour costs low enough to make a product which can compete in price with those from large automated firms, a considerable investment will have to be made in vacuum cookers, large capacity cookers with two-speed mixers, semi-automatic lines for rolling, moulding and cooling the sweets and enough machines to wrap those varieties requiring this, allowing one machine for each 0.8 ton produced daily. In calculating these quantities, consideration should be given to the fact that a wrapping machine set to handle a certain shape and type of sweet can take from fifteen minutes to three hours to alter it to suit another. Even if adjustment is possible, it is undesirable to make frequent alterations since they increase the risk of faults and disrupt the manufacturing process.

In Great Britain, the recommended ratio of manpower to product is traditionally two workers required for each ton of confectionery produced per week. This figure is based on the use of skilled labour and mechanical handling methods. It must be modified when unskilled labour and hand finishing methods are employed. For example, several small British firms producing three to five tons per week are known to have manpower ratios of three to four workers per ton per week due to the number of unskilled workers required for hand-packing. This suggests that the ratios of 5, 3 and 2.75 workers per ton per week obtained in the three models may be acceptable in countries that have low wage rates. A crucial factor in the manpower ratio is the decision made on the degree of wrapping required by the sweets. Although automatic wrapping machines cut labour requirements, they are a relatively large investment for a small firm, representing more than three times the capital investment in plant for model A and they require an output over half a ton a day for efficient utilisation. They require a high degree of standardisation of product and working conditions and need skilled maintenance. For all these reasons, as long as labour rates are low and output is small, recipes can be adjusted to produce sweets which do not require individual wrapping but are weighed by hand into large polythene bags. When conditions justify investment in a wrapping machine, a second-hand low-speed machine can be bought for a few hundred pounds. Many forty year-old machines are still working steadily, are simple to maintain and are readily available on the second-hand market. The modern trend towards fewer larger units of manufacture using completely automatic lines has made available a wide range of second-hand traditional sugar confectionery machinery. Some of the smaller machines are no longer manufactured in Britain but are in plentiful supply second-hand. Although there tends to be a risk involved in ordering second-hand machinery, the cost of new machinery is often so prohibitive that most small manufacturers in developing countries rely initially on obtaining second-hand units through recommended dealers, when prices may be about half those for new machinery when packing and freight costs are included. Quotations for the machinery given in the models were for prices ruling in 1970. Costs are increasing due to inflation and fresh quotations should be obtained for greater accuracy. A list of manufacturers and suppliers is given in Appendix 3. The type of plant for each scale was chosen on advice from machinery and confectionery manufacturers as being suitable for the manufacture of a typical range of sweets. Confectionery manufacturers use such a variety of acceptable methods that a wide choice of equipment is possible. Further advice is available from the sources of information listed in Appendix 3.

The smooth and uninterrupted flow of production is dependent upon the product having consistent characteristics. This consistency can only be maintained by the use of exact specifications for both raw materials and method. The major ingredients are sugar, glucose, fat and milk and the quality of any locally available inputs should be checked by confectionery experts when considering the feasibility of establishing a plant for the manufacture of high boiled sweets and toffees. It is likely that the other minor ingredients, colouring and flavouring agents, acids and emulsifiers will have to be imported together with reels of cellulose film wrapping paper since they are all specialist confectionery products. When considering the feasibility of an investment in confectionery production, due weight should be given to the availability of the necessary skilled labour as well as to the availability of raw materials and plant. Local conditions can vary widely in developing countries and it is always possible that unusually high import tariffs or distribution costs, for example, could make production uneconomic in a particular area.

A great deal of help in compiling this report has been given by manufacturers and suppliers of materials and machinery. They stress the importance of expert advice on choice of methods and welcome enquiries from overseas. A list of names and addresses is appended for sources of information. Advice on overseas problems is also given by experts in the trade journals which should be consulted in the planning stages. Experience in the field and expert advice are essential since this report is intended only as an introduction to a limited field of confectionery manufacture.

Operational data and notes on tables

The fundamental assumptions underlying the cost models are as follows:

1. The plant operates on one eight hour shift for five days a week, 250 days per year.
2. The operating efficiency is 80 per cent of the maximum throughput specified by machinery manufacturers and conforms to the opinion of experienced sugar boilers.
3. The models are set in a West African context and where possible factor costs have been locally obtained. Other costs have been adjusted suitably. All costs are given in £ sterling.
4. The prices quoted were those prevailing in 1970. Subsequent inflation will have affected machinery prices in particular and new quotations will be necessary to reflect the current situation.

TABLE 1: CAPITAL AND ANNUAL OPERATING COSTS, SALES AND RETURNS

The figures given in Table 1 can be derived for the most part from information given in Tables 2–8. Further explanations and supplementary tables are given below:

Row 2 – Buildings:

- Scale A – 1,000 sq ft at £2.92 per sq ft
- Scale B – 3,500 sq ft at £2.92 per sq ft
- Scale C – 12,000 sq ft at £3.5 per sq ft

It is assumed that model C is sited in the vicinity of a large town where a higher building rate would apply. Land is rented and included in miscellaneous items, row 14.

Row 3 – Plant: if spares excluded A = £1,700, B = £26,700, C = £69,000 adjusted figure required for calculation of repairs and maintenance, row 13.

Row 4 – Installation: 10 per cent fob prices of plant

Row 5 – Vehicles: see transport row 12

Row 7 – Working capital: two month's running costs

Row 12 – Transport: costs were obtained from local sources and are based on the following assumptions:

- Scale A – one small van costing £1,200 travels an average distance of 30 miles per day collecting some supplies and delivering 0.25 tons of sweets per day to retailers. The van uses one gallon of fuel per 25 miles at £0.23 per gallon.

Scale B — one 1½ ton truck costing £1,800 travels an average distance of 50 miles per day collecting some supplies and delivering one ton of sweets per day to retailers and wholesale depots. The truck uses one gallon of fuel per 20 miles at £0.23 per gallon.

Scale C — two 3 ton trucks costing altogether £4,700 travel on average a total distance of 200 miles per day delivering 4 tons of sweets per day to wholesale depots which supply a wide area of the country. The trucks use one gallon of fuel per 15 miles at £0.23 per gallon.

Annual transport costs including fuel, insurance, tax, maintenance and tyres replacement:

Scale A — £300: Scale B — £400: Scale C — £1,500.

Row 13 — Repairs and maintenance: 5 per cent of initial cost of buildings plus plant excluding spares, see note to row 2.

Row 14 — Miscellaneous: includes an estimated figure to cover office expenses and rent for land and insurance.

Office and other expenses A = £100, B = £300, C = £600.

Rent for land: row 1 Table 6 and page 25

Insurance: 0.25 per cent of value of buildings, row 4

0.45 per cent of value of plant, row 2

0.75 per cent of value of stock, two months ingredients and supplies, one sixth of rows 8—9.

Row 18 — Excise duty: £21.8 per ton of product

Row 21 — Depreciation: 10 per cent of plant row 2; 5 per cent of buildings row 4, 33⅓ per cent of vehicles row 5.

Row 23 — Sales revenue: has been based on 60 per cent of the current retail price of £0.243 per lb obtained for this type of confectionery in some parts of West Africa, where sweets are often sold individually in the local shops. Distribution costs can be very high in developing countries and a 40 per cent allowance has been made for this reason.

Sales A = 50 tons, B = 250 tons, C = 1,000 tons.

TABLE 2: RATE OF RETURN ON CAPITAL INCLUDING TAX AND ALLOWANCES FOR NEW AND USED MACHINERY

This table is developed from Table 1 and the figures for new machinery are shown in columns b, d and f. The figures for second-hand machinery shown in columns c, e and g, have been obtained similarly. The estimated total outlays on second-hand plant cif West Africa were as follows:

A — £700; B — £12,200; C — £30,400

The prices for second-hand confectionery machinery and equipment cif West Africa quoted by suppliers, average half the new ex-factory price in Britain, but these obviously vary with the condition and type of the equipment in question. For safety reasons, steam boilers are not recommended to be bought second-hand.

Row 2 — Annual allowances: tax-free allowances for buildings, 5 per cent total cost; plant and installation, 10 per cent total cost. Table 1, rows 2, 3 and 4.

Row 4 — Company tax: 40 per cent of taxable gross profit.

Row 9 – Initial allowances: a tax-free allowance is given for the first year only on investment in buildings of 10 per cent total cost and on investment in plant and installation of 15 per cent total cost. The tax rebate on these allowances, 40 per cent of the total tax-free allowance on buildings, plant and installation, is subtracted from the total investment to give an adjusted figure for investment, used when calculating rates of return on capital, after tax. These allowances are shown in Table (e) below:

Table (e)
Tax rebate on initial allowances

£'000 sterling 1970						
	Scale A		Scale B		Scale C	
	new m/c	used m/c	new m/c	used m/c	new m/c	used m/c
40 per cent tax rebate on:						
(a) 10 per cent of cost of building	0.1	0.1	0.4	0.4	1.7	1.7
(b) 15 per cent of cost of plant and installation	0.1	0.05	1.8	0.8	4.6	2.0
Total tax rebate	0.2	0.2	2.2	1.2	6.3	3.7

Row 11 – Rate of return on capital: these results are discussed in Chapter 3, pages 16–17.

TABLES 3, 4 AND 5: COST OF EQUIPMENT FOR SCALES A, B AND C

Quotations given in these tables are for prices ruling in 1970. Insurance and freight are calculated as being 10 per cent of the price fob British port. Duty is added at 5 per cent cif price. An allowance for spares of 3–5 per cent of the cost of machinery is recommended by the manufacturers. The calculation of kVA rating is explained below in the notes to Table 6, row 3. The choice of of machinery is discussed in Chapter 4, pages 21–22.

TABLE 6: LAND, FLOORSPACE, SERVICES, VEHICLES, LABOUR REQUIREMENTS AND COSTS FOR SCALES A, B AND C

Row 1 – Land rent: assume area of land required to be double the area of land occupied by the building. The rents reflect the variation in land values between rural and more urban sites.

Row 2 – Floorspace: it is assumed that model C is sited in the vicinity of a large town where a higher building rate would apply. Building floor areas were estimated from the space requirements of the machinery, in consultation with an expert in confectionery production.

Row 3 – Electricity: the standing charge is calculated from the maximum possible power demand from the plant installed, called kVA rating, and is independent of actual running time. It is charged on a monthly basis. Using the relationship:

1 horse power (hp) = 0.746 kilowatt (kW)
and kVA = kW

the standing charge can be calculated from the total power ratings given in Appendix 2, Tables 3, 4 and 5. The running charge is calculated from the total number of kilowatt-hours, kWh, used by the plant. For this type of machinery the following equation can be used:

kWh = kW x h

The running time for each machine was estimated for the required daily output using the data from Table (f) page 26 and Tables 3, 4 and 5 and allowing for 80 per cent efficiency of maximum throughput. From these data, the daily power requirements in kWh was calculated for each machine.

- Row 4 — Fuel oil: stove A 2 gal per hr per 3 hr day
 steam boiler B 3.6 gal per hr per 9 hr day
 steam boiler C 5.4 gal per hr per 9 hr day
- Row 5 — Water: estimated to include allowances for recipes, vacuum cookers, boilers and workers.
- Row 6 — Vehicles: see notes to Table 1 row 12 page 23
- Rows 7
 and 8 — Labour: see Table 8

TABLE 7: QUANTITIES AND COSTS OF RAW MATERIALS AND SUPPLIES FOR SCALES A, B AND C

Most of the cif prices in this table have been calculated from the prices fob British port, by the addition of 10 per cent for freight and insurance. The quotations for sugar and cartons were obtained from local West African sources.

Rows 1–8 — Ingredients: The quantities are calculated from the product mix and recipes given in the following table:

Table (f)
Typical product mix and recipes for manufacture of high boiled sweets and toffees

	Scale A	Scale B	Scale C
Total output: (a) tons per year	50	250	1,000
(b) tons per 8 hour day	0.2	1	4
High boiled sweets: (a) tons per year	30	150	600
(b) tons per 8 hour day	0.12	0.6	2.4 ⁽¹⁾
recipe as percentage of total			
(a) sugar	70	60	60
(b) glucose	30	40	40
(c) acid	1.5	1.5	1.5
(d) flavouring and colouring agents	(2)	(2)	(2)
Toffees: (a) tons per year	20	100	400
(b) tons per 8 hour day	0.08	0.4	1.6
recipe as percentage of total			
(a) sugar	30	30	30
(b) glucose	40	40	40
(c) milk product	15	15	15
(d) fat	15	15	15
(e) salt	0.5	0.5	0.5
(f) lecithin	0.1	0.1	0.1
(g) flavouring agent	(2)	(2)	(2)

footnotes: ¹ this includes 0.4 ton centre filling cooked in steam pan
² due to wide variation in prices and concentrations, average cost of flavour and colour per ton of product is used.

- Row 4 — Milk: sweetened, condensed, skimmed.
 Scale A and B in 28 lb tins; scale C in 0.25 ton drums.
- Rows 5
 and 6 — Flavouring and colouring: due to wide variations in prices and concentrations, average cost of flavour per ton of sweet produced is taken as £2 cif West Africa and average cost of colour per ton of high boiling is taken as £0.45 cif West Africa.
- Row 8 — Other ingredients: salt and lecithin for toffee manufacture: french chalk for general use to prevent sweets from sticking.
 Estimated figures.

- Row 9 – Plastic bags: capacity 5 lb sweets.
 Cartons: capacity 30 lb sweets per carton, 75 cartons per ton. Half the cartons are returned for a second trip thus reducing requirements to 50 cartons per ton.
- Row 10 – Wrapping paper: wrapping machines require on average 0.05 ton paper per ton of sweet wrapped. A – no machine, B – 1 machine, C – 4 machines.

TABLE 8: DETAILS OF PERSONNEL AND EARNINGS FOR SCALES A, B AND C

The amount of labour required was estimated from advice given by working managers in the trade. Wage rates were those current in a West African country 1970 and include an allowance for insurance contributions. The effect of increased labour costs on profits is discussed in Chapter 3, analysis of models.

The number of workers required depends on the degree of skill available and on the product chosen: if there is more handwork involved in finishing and packing, the labour ratio will increase. The manpower requirements in these models assume the minimum finishing processes and no hand wrapping of sweets or toffees.

Tables

Table 1

Capital and annual operating costs, sales and returns

Operating 8 hour day, 250 days per year. Annual outputs A = 50 tons, B = 250 tons,
C = 1,000 tons

Values in £'000
sterling 1970

Projected outputs		Scale A	Scale B	Scale C	Notes
a		b	c	d	e
1	Total investment	8.4	53.8	164.6	Sum of rows 2 to 7.....
2	Buildings	2.9	10.2	42.0	cif prices from Tables 3—5..
3	Plant including spares	1.7	27.7	71.5	
4	Installation	0.2	2.4	6.2	
5	Vehicles	1.2	1.8	4.7	10% rows 2 to 5.....
6	Unforeseen	0.6	4.2	12.4	
7	Working capital	1.8	7.5	27.9	One sixth of sum of rows 8 to 15
<i>Annual operating costs</i>					
8	Ingredients	4.6	22.9	91.1	Table 7
9	Supplies	0.3	5.2	26.2	Table 7
10	Power and fuel	0.3	2.8	5.9	Table 6
11	Labour (a) direct	1.6	4.4	14.5	Table 8
	(b) indirect	2.3	2.6	5.3	
12	Transport	0.3	0.4	1.5	
13	Repairs and maintenance	0.2	1.8	5.6	
14	Miscellaneous	0.2	0.6	1.8	
15	Unforeseen	1.0	4.1	15.2	10% rows 8 to 14
16	Interest on working capital	0.2	0.7	2.5	9% row 7.....
17	<i>Total annual operating costs</i>	<u>11.1</u>	<u>45.5</u>	<u>169.7</u>	Sum of rows 8 to 16
18	Excise duty	1.1	5.4	21.8	
19	Sales staff	—	—	2.9	Table 8
20	<i>Total annual sales costs, excl. depreciation</i>	<u>12.2</u>	<u>50.9</u>	<u>194.4</u>	Sum of rows 17 to 19
21	Depreciation	0.7	3.9	10.8	
22	<i>Total annual sales costs incl. depreciation</i>	<u>12.9</u>	<u>54.8</u>	<u>205.2</u>	Sum of rows 20 and 21
23	<i>Sales revenue</i>	<u>16.3</u>	<u>81.6</u>	<u>326.6</u>	
24	Taxable gross profit excl. depreciation	4.2	30.7	132.2	Row 23 minus row 20
25	Taxable gross profit incl. depreciation	3.5	26.9	121.4	Row 23 minus row 22
26	Rate of return on capital before tax incl. depreciation	41%	50%	74%	Row 25 as % of row 1
27	Rate of return on capital after tax and all allowances	23%	31%	46%	See Table 2 row 11.....
28	Capital recovery period	3.0 years	2.6 years	1.9 years	See Table 2 row 12.....

Sources:

Appendix 1 page 23

Footnotes:

— sub-total

— nil, negligible or not applicable

Table 2
Rate of return on capital including tax and allowances, for new and used machinery

Values in £'000 sterling 1970									
	a	Scale A		Scale B		Scale C		Notes	
		new b	used c	new d	used e	new f	used g		
1	Taxable gross profit excluding depreciation	4.2	4.3	30.7	31.7	132.2	134.7	Table 1 row 24 and notes to Table 2	
2	Annual allowances	0.3	0.2	3.5	1.8	9.9	5.4		
3	Adjusted taxable gross profit	3.9	4.1	27.2	29.9	122.3	129.3	Row 1 minus row 2	
4	Company tax	1.6	1.6	10.9	12.0	48.9	51.7	40% row 3	
5	Net profit after tax	2.6	2.7	19.8	19.7	83.3	83.0	Row 1 minus row 4	
6	Depreciation	0.7	0.6	3.9	2.3	10.8	6.7	Table 1 row 21	
7	Net profit after tax and depreciation	1.9	2.1	15.9	17.4	72.5	76.3	Row 5 minus row 6	
8	Total investment	8.4	7.2	53.8	35.0	164.6	115.1	Table 1 row 1	
9	Tax rebate on initial allowances	0.2	0.2	2.2	1.2	6.3	3.7		
10	Total investment adjusted for initial allowances	8.2	7.0	51.6	33.8	158.3	111.4	Row 8 minus row 9	
11	Rate of return on capital after tax and depreciation	23%	30%	31%	51%	46%	68%	Row 7 as a % of row 10	
12	Capital recovery period	3 years	2.6 years	2.6 years	1.7 years	1.9 years	1.3 years	Row 10 divided by row 5	

Sources:
Appendix 1 page 24

Table 3

Quantities and costs of equipment and power rating for scale A

Values in £ sterling 1970

List of equipment	Unit maximum capacity	Total power rating	Estimated daily running time hours ⁽¹⁾	fob price £
a	b	c	d	e
1 Oil-fired stove	56 lb Syrup per 20 mins			
	2 gal fuel oil/hr	2 hp	3	580
2 Oil storage tank	500 gal	—	—	40
3 2 copper boiling pans	56 lb	—	—	110
4 Cast iron pouring plate with stand	6 ft x 3 ft	—	—	120
5 Drop roller with stand motor driven	280 lb/hr	0.75 hp	1	220
6 2 pr 7 in drop rollers	—	—	—	260
7 Caramel cutter hand operated	—	—	—	50
8 Sundry equipment	—	—	—	90
9 Spares	—	—	—	40
10 Total	—	2 kVA	—	1,510
11 Insurance and freight	—	—	—	150
12 Total cif	—	—	—	1,660
13 Duty	—	—	—	80
14 Total outlay	—	—	—	1,740

Source:

Machinery manufacturers
Appendix 1 page 25

Footnotes:

(1) assuming an operating efficiency of
80 per cent, see page 23
— nil, negligible, not applicable
— sub-total

Table 4

Quantities and costs of equipment and power rating for scale B

Value in £ sterling 1970

List of equipment	Unit maximum capacity	Total power rating	Estimated daily running time hours ⁽¹⁾	fob price £
a	b	c	d	e
1 Steam boiler, oil-fired	500 lb per hr	1 hp + 1.5 kW	9	1,230
2 2 oil storage tanks	500 gal	—	—	80
3 Batch vacuum cooker	1.2 tons per 8 hr	6 hp	6	3,080
4 Steam jacketed pan with two-speed stirrers	84 lb per 15 min	{ 1.5 hp 0.75 hp	{ 4 ½	2,790
5 4 two-handled aluminium pans	56 lb	—	—	150
6 3 watercooled plates 6 ft x 3 ft with stands	—	—	—	950
7 Hotplate 6 ft x 3 ft with stand	—	—	—	320
8 2 sailcloth covers for hotplate	—	—	—	40
9 Pulling machine	56 lb	3 hp	2	840
10 Rock chopping machine hand operated	—	—	—	240
11 Caramel cutter hand operated	—	—	—	50
12 Batch roller, rope sizer, feed table	112 lb	1.5 hp + 200 W	8	2,460
13 Plastic sweetformer, set of dies	1.1 tons per 8 hr	1 hp + 300 W	6	2,050
14 Three tier cooler with blower	1.1 tons per 8 hr	1.8 hp	6	2,560
15 (a) Drop roller machine, motor driven	280 lb per hr	0.75 hp	8	220
(b) Two pairs 7 in. drop rollers	—	—	—	260
16 Sundry equipment	—	—	—	230
17 Twist-wrapping machine, hand feed	0.6 tons per 8 hr	0.75 hp + 300 W	8	5,000
18 Two air cooling units	16,000 BThU per hr	3 hp + 4.4 kW	16	420
19 Dehumidifier	—	1.2 kW	24	130
20 Spares	—	—	—	920
21 Total	—	24 kVA	—	24,020
22 Insurance and freight	—	—	—	2,400
23 Total cif	—	—	—	26,420
24 Import duty	—	—	—	1,320
25 Total outlay	—	—	—	27,740

Sources:

Machinery manufacturers
Appendix 1 page 25

Footnotes:

(1) assuming an operating efficiency of
80 per cent, see page 23
— nil, negligible or not applicable
— Sub-total

Table 5
Quantities and costs of equipment and power rating for scale C

Values in £ sterling 1970

List of equipment		Maximum unit capacity	Power rating	Estimated daily running time hours ⁽¹⁾	fob price £
a		b	c	d	e
1	Steam boiler, oil-fired	750 lb per hr	1.25 hp + 1.5 kW	9	1,750
2	2 oil storage tanks	500 gal	—	—	80
3	2 batch vacuum cookers	1.2 ton per 8 hr	12 hp	8	6,160
4	Steam jacketed pan with two speed stirrers	280 lb per 20 min	{ 2 hp + 0.75 hp	{ 8 1½	3,290
5	8 two-handled aluminium pans	56 lb	—	—	300
6	12 water-cooled plates 6 ft x 3 ft with stands	—	—	—	3,820
7	4 hot plates 6 ft x 3 ft with stands	—	—	—	1,270
8	6 sailcloth covers for hot plate	—	—	—	110
9	Pulling machine	112 lb	5 hp	4	1,110
10	2 caramel cutters, hand operated	—	—	—	100
11	3 batch rollers, rope sizers, feed tables	112 lb	{ 4.5 hp 600 W	8	7,380
12	2 plastic sweet formers with 2 sets of dies	1.1 ton per 8 hr	2 hp	8	4,100
13	2 three-tier coolers with blowers	1.1 ton per 8 hr	3.6 hp	8	5,120
14	(a) 2 motor-driven drop roller machines	280 lb per hr	1.5 hp	8	440
	(b) 4 pairs 7 in. drop rollers	—	—	—	520
15	Sundry equipment	—	—	—	500
16	Toffee cut-and-wrap machine	1 ton per 8 hr	{ 3 hp 150 W	8	7,000
17	3 twist-wrapping machines, hand feed	0.6 ton per 8 hr	{ 2.25 hp 900 W	11	15,000
18	6 air-cooling units	16,000 BThU per hr	{ 9 hp 13.2 kW	16	1,270
19	3 de-humidifiers	—	3.6 kW	24	390
20	Spares	—	—	—	2,160
21	Total	—	55 kVA	—	61,870
22	Insurance and freight	—	—	—	6,190
23	Total cif	—	—	—	68,060
24	Import duty	—	—	—	3,400
25	Total outlay	—	—	—	71,460

Sources:
Machinery manufacturers
Appendix 1 page 25

Footnotes:
(¹) assuming an operating efficiency of
80 per cent, see page 23
— nil, negligible or not applicable
— — — sub-total

Table 6

Land, floorspace, services, vehicles, labour requirements and costs for scales A, B and C

Values in £ sterling 1970										
	Inputs	Unit	Scale A		Scale B		Scale C			
			Cost in £ per unit	Units per year (1)	Cost in £ per year (1)	Units per year (1)	Cost in £ per year (1)	Units per year (1)		
	a	b	c	d	e	f	g	h	i	
1	Land rent									
	(a) Scale A	'000 sq ft	2.3	2	5	—	—	—	—	—
	(b) Scale B	'000 sq ft	13.8	—	—	7	100	—	—	—
	(c) Scale C	'000 sq ft	27.5	—	—	—	—	24	660	—
2	Floorspace									
	(a) Scale A	sq ft	2.92	1,000	2,920	—	—	—	—	—
	(b) Scale B	sq ft	2.92	—	—	3,500	10,220	—	—	—
	(c) Scale C	sq ft	3.50	—	—	—	—	12,000	42,000	—
3	Electricity									
	(a) Standing charge	kVA	1.75 per month	2	40	24	500	55	1,150	—
	(b) Running charge	kWh	0.0146	2,000	30	58,000	850	163,000	2,380	—
4	Fuel oil	gal	0.175	1,500	260	8,100	1,420	12,150	2,130	—
5	Water	'000 gal	0.292	—	—	240	70	720	210	—
6	Vehicles									
	(a) Scale A	light van	1,200	1	1,200	—	—	—	—	—
	(b) Scale B	1½ ton truck	1,800	—	—	1	1,800	—	—	—
	(c) Scale C	3 ton truck	2,350	—	—	—	—	2	4,700	—
7	Direct labour	person	—	5	1,580	16	4,350	55	14,500	—
8	Indirect labour	person	—	1	2,330	2	2,560	5	5,340	—

Sources:

Machinery manufacturers
Confectionery manufacturers
Appendix 1 page 25

Footnotes:

(1) Where applicable
— nil, negligible or not applicable

Table 7

Quantities (¹) and costs of raw materials and supplies for scales A, B and C

Values in £ sterling 1970										
Inputs	Unit	Scale A			Scale B			Scale C		
		Cost in £ per unit		Units per year	Cost in £ per year	Units per year	Cost in £ per year	Units per year	Cost in £ per year	
a	b	fob	cif	d	e	f	g	h	i	j
<i>Ingredients</i>										
1 Sugar (a) HB ⁽²⁾	long ton	—	80.5		21	1,690	90	7,240	360	28,980
(b) T ⁽²⁾	long ton	—	80.5		6	480	30	2,420	120	9,660
2 Glucose (a) HB	long ton	60	66		9	590	60	3,960	240	15,840
(b) T	long ton	60	66		8	530	40	2,640	160	10,560
3 Fat T	long ton	200	220		3	660	15	3,300	60	13,200
4 Milk T	long ton	{134	147		3	440	15	2,200	—	—
	long ton	{126	139		—	—	—	—	60	8,340
5 Flavouring (a) HB	long ton of	1.9	2		30	60	150	300	600	1,200
(b) T	sweet product	1.9	2		20	40	100	200	400	800
6 Colouring HB	long ton of	0.35	0.45		30	10	150	70	600	270
	sweet product									
7 Acid HB	long ton	215	237		0.45	110	2.25	530	9	2,130
8 Other ingredients	—	—	—		—	10	—	50	—	140
<i>Supplies</i>										
9 Containers										
(a) Plastic bags	'000	3.5	3.9		22.5	90	112.5	440	450	1,750
(b) Cartons	'000	—	93.3		2.5	230	12.5	1,170	50	4,660
10 Wrapping paper	long ton	515	567		—	—	6.25	3,540	35	19,840

Sources:

Manufacturers and importers

Chapter 1 Method and Appen

Footnotes:

(1) assuming an operating efficiency of 80 per cent, see page 23

(2) used to distinguish ingredients for manufacture of high boiled sweets HB and Toffees T, detailed in Appendix 1 page 26

nil, negligible or not applicable

Table 8

Details of personnel and earnings for scales A, B and C

Values in £ sterling 1970										
		Labour requirements			Wage rate per head per year £			Total cost per year £		
		Scale A b	Scale B c	Scale C d	Scale A e	Scale B f	Scale C g	Scale A h	Scale B i	Scale C j
		a								
<i>Direct labour</i>										
1	Sugar boiler	1	1	2	700	700	930	700	700	1,860
2	Skilled assistant	1	3	10	350	350	350	350	1,050	3,500
3	Semi-skilled worker	—	3	13	—	220	220	—	660	2,880
4	Unskilled worker	3	7	26	180	200	200	530	1,390	5,160
5	Driver and maintenance	—	1	2	—	350	350	—	350	700
6	Driver's mate	—	1	2	—	200	200	—	200	400
	Total direct labour	5	16	55	—	—	—	1,580	4,350	14,500
<i>Indirect labour</i>										
7	Manager/owner	1	1	1	2,330	2,330	3,500	2,330	2,330	3,500
8	Maintenance engineer	—	—	1	—	—	700	—	—	700
9	Clerk	—	1	2	—	220	220	—	220	440
10	Foreman	—	—	1	—	—	700	—	—	700
	Total indirect labour	1	2	5	—	—	—	2,330	2,560	5,340
	Total labour	6	18	60	—	—	—	3,910	6,910	19,850
<i>Sales staff</i>										
11	Sales manager	—	—	1	—	—	1,800	—	—	1,800
12	Sales man	—	—	2	—	—	560	—	—	1,120
	Total sales staff	—	—	3	—	—	—	—	—	2,920

Sources:

Confectionery manufacturers
Appendix 1 page 27

Footnotes:

— nil, negligible, not applicable
--- sub-total



Suppliers, sources of information and conversion factors

LIST OF SUPPLIERS AND SOURCES OF INFORMATION

Information on suppliers of machinery, equipment and other requirements of the sugar confectionery industry may be found in the journal 'Confectionery Production' published monthly by Specialised Publications Ltd, 5 Grove Road, Surbiton, Surrey, England. This journal runs a Readers Problem Service which is free to subscribers and all enquiries from overseas should be addressed to: Problem Department, Confectionery Production, 5 Grove Road, Surbiton, Surrey, England.

Machinery and equipment

- 1 Brierley, Collier and Hartley Equipment Ltd
Rochdale, Lancashire, England
Small and large scale machinery and equipment
- 2 Baker Perkins Latin America Ltd
Seacroft, Leeds, England
Twist wrapping machines
- 3 Hamac-Hansella Maschinen GmbH
4000 Dusseldorf, Cecilienallee 17, Germany
Vacuum cookers, small and large scale machinery and equipment
- 4 Perkins Boilers Ltd
Derby, England
Steam boilers
- 5 Temperature Ltd
York Road, London SW11, England
Air conditioning

Materials and supplies

- 1 British Visqueen Ltd
Stevenage, Hertfordshire, England
Polythene bags
- 2 Bush Boake Allen Ltd
28 Ash Grove, London E8, England
Colours and flavours
- 3 Corn Products Sales Ltd
Claygate House, Esher, Surrey, England
Glucose syrup
- 4 Croda Food Products Ltd
168 High Holborn, London WC1, England
Acids and emulsifiers

- 5 Loders and Nucoline Ltd
15 Dorset Rise, London EC4, England
Confectionery fat
- 6 Transparent Paper Ltd
126 Cromwell Road, London SW7, England
Cellulose film for twist-wrapping

Research association

The British Food Manufacturing Industries Research Association, Leatherhead, Surrey, England

Reference books

- 1 *“Chocolate, Cocoa and Confectionery”*
B W Minifie
Churchill, London 1970, 625pp.
Deals with modern aspects of confectionery technology, shelf life and storage problems.
- 2 *“Chocolate and Confectionery”*
C T Williams
Hill, London 1964, 222pp.
A text book for students and a reference book for manufacturers.
- 3 *“Silesia Confiserie Manual No. 1 Handbook for the Sugar Confectionery Industry”*
A Meiners and H Joike
Silesia Gerhard Hanke K G, 4041 Norf, West Germany 1969, 528pp. in four languages, English, German, French and Spanish.
A manual on factory planning and production methods. including a comprehensive list of international machinery manufacturers, publications and conversion tables together with 200 pages of machinery illustrations.
- 4 *“Skuse’s Complete Confectioner”*
Elsevier Scientific Publishing Co, Barking, Essex, England, Thirteenth edition 1957, 344pp.
A standard reference book of recipes for the small scale manufacturer of confectionery.

CONVERSION FACTORS

Metric Units	British Imperial Units
1. <i>Linear Measures</i> 1 metre = 39.37 inches 1 metre = 3.28084 feet 1 kilometre = 3,280.84 feet = 0.621372 mile	1 inch = 0.0254 metre 1 foot = 0.3048 metre 1 mile = 5,280 feet = 1.609344 kilometres
2. <i>Square Measures</i> 1 sq metre = 10.763911 sq ft 1 hectare = 10,000 sq metres 1 hectare = 11,959.89 sq yards = 2.471052 acres	1 sq foot = 929.0304 sq centimetres 1 sq foot = 0.092903 sq metre 1 acre = 43,560 sq feet = 4,840 sq yd 1 acre = 4,046.86 sq metres = 0.404686 hectare
3. <i>Measures of Capacity</i> 1 litre = 0.219976 imperial gallon 1 litre = 0.264178 US gallon	1 imperial gallon = 4.545963 litres 1 imperial gallon = 277.42 cubic in 1 imperial gallon = 0.160544 cubic ft 1 imperial gallon = 1.20095 US gal

4. *Weight Measures*

1 kilogram = 2.204622 pounds

1 metric ton = 0.984207 long ton

1 pound = 0.453592 kilogram

1 ton (long ton) = 2,240 pounds

1 long ton = 1.01605 metric ton

5. *Electric Power*

1 kilowatt (kW) = 1,000 Watts

1 kilowatt x 1 hour = 1 kilowatt
hour (kWh)

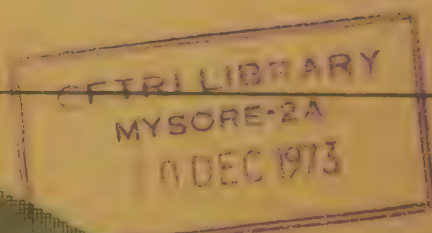
1 horse power (h.p.) = 0.746 kilowatt (kW)

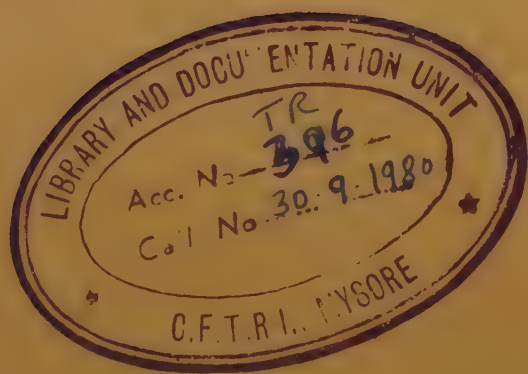




G78

**Development of a Wet-Coconut
Process designed to extract
protein and oil from fresh coconut**





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D. A. V. Dendy and W. H. Timmins

This report was produced by the Tropical Products Institute, a British Government organization which helps developing countries to derive greater benefit from their renewable resources.

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The assistance of other sections of the Tropical Products Institute is acknowledged, in particular our colleagues in the Food Department, Engineering Section, Cellulosic Products Section, Industrial Economics Section and the Bakery Sub-Section.

Summaries

SUMMARY

The presented work describes the investigations carried out by TPI on the technical aspects of extracting oil and protein from fresh coconut. The principal objective of the studies was to develop a working process to extract the oil and protein; however it is hoped that this report will also provide an insight into some of the difficulties to be encountered in this, and similar areas of research. The two basic stages of the process, namely the aqueous extraction of the protein and oil from the fresh kernel to produce an emulsion and the subsequent resolution of the emulsion into its constituents, have been intensively studied and optimum processing conditions established. It has been shown that the extraction of the oil and protein from the kernel is primarily dependent upon the percentage of kernel cells ruptured during the wet-milling operation. Regarding recovery of the oil and protein from the emulsion, the important processing feature relates to the fact that the emulsion is a fourphase system and is basically very stable.

The overall yield (using small-scale equipment) from the process is around 85 per cent for both the oil and the protein: this would seem in the first instance, to be better than the average overall yield (from tree to refined oil) for the copra process as it is normally operated. However an economic evaluation of the wet-coconut process carried out by the Industrial Economics Section of TPI (published as TPI Report G 79), illustrates the fact that, providing the processing of copra is carried out efficiently, it remains the most economically viable means of extracting oil from coconut.

Evaluation of the products obtained from the TPI wet-coconut process has shown the oil to be of high quality and has indicated the nutritional efficacy of using the protein isolate to enrich bread manufactured from composite flours.

SOMMAIRE

Cet ouvrage comprend la description des études réalisées par le Tropical Products Institute (Institut des Produits Tropicaux) sur les aspects techniques d'extraction de l'huile et de la protéine de la noix de coco fraîche. Ces études avaient pour objet principal la mise au point d'un procédé de traitement qui permettrait d'extraire l'huile et la protéine; on espère cependant que le compte rendu de ces études fournira également un aperçu de quelques unes des difficultés auxquelles on doit faire face dans ce domaine ainsi que dans d'autres domaines semblables de recherche. On a étudié intensivement les deux stades fondamentaux du traitement, à savoir, l'extraction aqueuse de la protéine et de l'huile de l'amande fraîche pour en produire une émulsion et, par la suite, la résolution de l'émulsion en ses éléments constitutants; on a ensuite déterminé l'optimum des conditions de traitement. On a constaté que l'extraction de l'extraction de l'huile et de la protéine de l'amande dépend essentiellement du pourcentage de cellules de l'amande qui éclatent au cours du moulage à

l'eau. En ce qui concerne la récupération de l'huile et de la protéine à partir de l'émulsion, le trait caractéristique important du traitement se rapporte au fait que l'émulsion, étant quaternaire, est au fond très stable.

Le rendement global (en se servant de matériel à petite échelle) produit par le traitement est de l'ordre de 85 pour cent pour à la fois l'huile et la protéine/ il semblerait au premier abord que ce taux est supérieur au rendement global moyen (depuis l'arbre jusqu'à l'huile raffinée) obtenu par le traitement du coprah, tel qu'il s'effectue normalement. Toutefois, une étude économique réalisée par le Service de l'Economie Industrielle du TPI (publiée sous le numéro G79) évaluant le traitement de la noix de coco à l'eau démontre qu'à condition que le traitement du coprah soit réalisé de manière efficace, il reste, sur le plan économique, le moyen le plus viable d'extraire l'huile de la noix de coco.

Une évaluation des produits obtenus à partir du procédé du TPI pour le traitement à l'eau de la noix de coco a montré que l'huile était de qualité excellente et a indiqué l'efficacité nutritive de l'utilisation de la protéine isolée pour enrichir le pain fabriqué de farines composées.

RESUMEN

El presente trabajo relaciona las investigaciones llevadas a cabo por TPI acerca de los aspectos técnicos de extracción de aceite y proteína procedente de coco fresco. El fin que se persigue con los estudios es el de crear un método de elaboración de aceite y proteína, no obstante se espera que este informe deje al descubierto algunas de las dificultades que se han de encontrar en ésta y en otras esferas de investigación. Las dos fases básicas del proceso que son la extracción acuosa de la proteína y aceite del coco fresco para producir una emulsión, y la subsiguiente redisolución de la emulsión en sus elementos constitutivos, han sido objeto de profundo estudio y se han definido cuales son las más óptimas condiciones de elaboración. Se he mostrado que la extracción del aceite y proteína del coco depende, primordialmente, del porcentaje de células del coco que se rompen durante la operación de molido en mojado. En lo que a la recuperación del aceite y proteína de la emulsión concierne, la importante característica de la elaboración se relaciona con el hecho de que la emulsión es un sistema de cuatro fases y es básicamente muy estable.

La producción total (empleando equipo en pequeña escala) derivada del proceso es alrededor del 85% para el aceite, así como para la proteína, pareciendo a primera vista ser mejor que el rendimiento total de promedio (de árbol a aceite refinada) para el proceso de copra tal y como se opera normalmente. Sin embargo, la valoración económica del proceso de coco mojado, llevada a cabo por la Sección Industrial de Económicas de TPI (publicada como Informe G 79 de TPI), ilustra el hecho de que siempre y cuando se realice en forma eficaz la elaboración de copra, continúa ésta siendo el método más ventajoso, económicamente hablando, de extraer aceite de coco.

La valoración de los productos obtenidos a través del proceso de coco mojado de TPI, ha demostrado que el aceite es de alta calidad, e indicado la eficacia nutritiva de la utilización del aislante de proteína para enriquecer el pan elaborado con harinas mixtas.

Preface and Introduction

PREFACE

Traditionally, the coconut is dried to produce copra and the oil is then obtained from the copra by expression or prepress solvent extraction methods. The residual product after the oil extraction — coconut meal — contains a moderate proportion of protein (18–25 per cent of the dry matter), but it is too fibrous for use at high levels in monogastric diets, and consequently its main use is in ruminant feeding. Further it has been shown that the quality of coconut protein is severely lowered by the conditions under which copra is usually processed for its oil.

With the increasing concern over the world food supply, considerable international attention has been directed towards the possible utilisation of coconut protein as a source for human food. Accordingly, numerous attempts have been made to develop a process to extract protein as well as oil from fresh coconuts. (Out of economic necessity all such processes have been designed to produce a protein isolate as a by-product of the oil extraction and, so far as is known, none has) proved economically viable.

INTRODUCTION

Coconut palms grow in the tropics on low-lying, drained land in regions of adequate rainfall. Prior to World War II, Indonesia was the most important producing area, but in post-war years the Philippines have emerged as the main producers, followed by Indonesia, India and Sri Lanka. (Data on world production of coconut and copra, and their geographical distribution are presented in Tables 1 and 2. These figures though a guide, take into account only processed fruits, the availability of fresh fruits being much higher. Many coconuts are consumed as such in the producing countries. This consumption of unprocessed nuts is generally estimated as lying between 18–50 per cent of the output of the main producing countries¹, although some countries — eg the Philippines (three per cent) and Thailand (90 per cent) — have consumptions which fall outside this range.

Interesting accounts of the early historical development of the coconut as a major cash crop are to be found in the books by Belfort & Hoyer², Coghlan and Hinchley³, Smith and Pape⁴, Sampson⁵ and Patel⁶; however, for a more modern description of the botanical, agricultural, and processing aspects of the coconut the reader is referred to the books written by Child⁷, Fremond⁸, Pandalai and Menon⁹ and Woodroof¹⁰.

The mature coconut consists of a husk (the “coir” of commerce) which totally covers the seed nut which is comprised of a hard outer shell enclosing the testa and the thick, white endosperm (meat). The cavity of the endosperm is filled, in the unripe fruit, with a watery fluid (coconut water). The distribution varies

with the maturity of the nut (Table 3) — in the fully mature nut the kernel represents 60 per cent and the water about eight per cent by weight.

The average composition of the mature kernel is shown in Table 4.

It appears that the first crude attempts at processing oilseeds occurred before the dawn of recorded history. Early Hindu writings refer to the pounding and subsequent boiling of cottonseed to recover the oil¹¹. The Ancient Chinese are said to have obtained the oil by reducing oilseeds to meal under an edgestone, heating the meal in an open pan and pressing in a wedge press¹². At later dates several types of lever presses and hand-powered screw presses were invented by the Greeks and Romans¹³. It is uncertain whether olive or coconut oil has been the longer in use¹⁴ but there can be no doubt that the extraction of oil from copra is one of the oldest seed-crushing industries in the world. These early efforts were prompted by the desire for the oil, but it seems likely that interest in, and utilisation of, the oilseed cakes as animal feed, followed soon thereafter.

Development of the hydraulic press marked a long stride forward in the commercial processing of oilseeds; such a press was patented in England in 1795 by Joseph Bramah¹⁵. The first factory for the extraction of oil from copra (the dehydrated coconut kernel) was erected in England by W Tindall in 1842 and about the same time the industry was introduced into France¹⁶. Leubuscher's review¹⁷ is perhaps the most comprehensive with regard to the earlier attempts at processing copra. Hydraulic processing became the predominant method in the oilseed industry and continued so until well into the 20th century. Its high labour requirements and less efficient recovery of oil have caused it to lose ground to continuous methods.

Continuous methods of processing, which include screw-pressing and prepress solvent extraction, were developed early in the 20th century¹³ — however, only a few continuous systems were operating prior to World War I. Screw-pressing became widely used in the United States after World War II — prepress solvent extraction followed quickly and it can almost be said that the two processes grew up together.

Most modern copra processing plants employ either one of these methods or a combination of both. As to which one is used, this is dependent upon local conditions and available capital. Generally speaking, a solvent extraction plant will require the higher capital investment¹. Oil yields based on the original starting material are between 90–95 per cent for the expeller units and over 95 per cent for the solvent extraction plants¹. The residual cake left after the oil extraction is sold as cattle fodder^{7 18}. Table 5 gives a typical analysis of copra, and the press-cake.

(Mitchell, Hamilton and Beadles¹⁹ and Curtin¹⁸ have reviewed nutritional studies on copra cake.) In recent years there has been increased interest in the possibility of using it as a source of protein for food^{20 21 22 23}.

The inherent disadvantages of using copra cake are many — for example:

- (i) The high fibre levels of the press cake (approx ten per cent) restricts its use as a direct protein supplement for monogastric diets^{27 28 29 30}.
- (ii) The cakes produced from screw presses are not good starting materials for the preparation of protein isolates as this method seriously discolours as well as denatures the protein¹⁸; Butterworth and Fox²⁵ and Fox²⁶ have conclusively demonstrated the deleterious affect of heat treatment on the nutritive value of coconut meal.
- (iii) Very often insufficient care is taken during the premilling preparation (ie the drying stage) of copra. Because of the humid conditions prevalent in the countries of production, the copra is subjected to degradation by micro-organisms²⁴. In itself this is sufficient reason to prevent the possible utilisation of copra press cake for human consumption.

Although the copra industry, as a whole, is relatively efficient for the purpose for which it has developed — that is, the extraction of oil—the losses of oil from tree to finished product can be considerable. Modern methods of copra drying using properly constructed kilns, and expelling the oil from the copra soon afterwards, lead to high-grade oil with minimal losses. With less care, losses can amount to as much as 30 per cent of the oil that was in the freshly harvested nut, with the losses made up as follows:

- (a) Up to ten per cent may be lost due to microbial spoilage during the drying stage^{31 32}.
- (b) Up to ten per cent may be lost by insect and rodent attack during drying, storage and transportation³¹.
- (c) Around five per cent of the oil remains in the copra cake after expelling (some countries employ solvent extraction techniques to recover this oil, and in so doing produce copra meal).
- (d) Generally, oil produced from copra has to be refined due to development of free fatty acids (FFA) in the copra during the drying stage. Depending on the FFA content of the copra, around five per cent of the oil may be lost during the oil refining operation³³.

In the light of the above, it seems somewhat surprising that alternative means of processing coconut have not proved to be economically viable: one reason for this would seem to be a lack of effective transfer from laboratory via pilot plant to production^{33 34}.

However, in recent years, there has been widespread interest in processing fresh coconut (as opposed to copra) for both the oil and the protein contained therein, and processes devised to this end are now reviewed.

Wet-coconut processing: a review of existing methods

The basic principles engendered in the majority of the "modern" wet processes, are those which were first used in ancient times^{1 35}. That is, to obtain an emulsion (or "milk") from the coconut meats and to break this down to obtain oil.

The crux of the whole problem of wet-processing of fresh coconuts, is the separation of the emulsion into its constituents. This cannot be done simply by boiling — as with the primitive methods — because a protracted boiling process would seriously damage the quality of the protein and of the oil.

A common feature of the various modern processes is, therefore, the use of centrifugal separators for the recovery of the oil and protein. The processes differ, however, in many details — especially in the pretreatment of the emulsion. Treatments that are used, or have been suggested, include: coagulation of the proteins by heating, refrigeration, action of enzymes, acidification; use of salt or brine; electrolytic action, and shock waves. Combinations of these techniques have also been tried — with varying degrees of success. The two features common to all wet-processing methods are:—

- (i) Production of an emulsion (all the processes utilise the fact that coconut contains a "ready-made" emulsification system, namely oil, water and surface-active agent — the protein).
- (ii) The breaking of this emulsion in order to recover the oil and protein. Some wet-processes will now be described.

MAJOR WET-PROCESSES

(a) **The Chayen process (or the Impulse-rendering process)** — for the flow diagram see Figure 1.

This process was originally developed by the British Glues and Chemicals Company Limited (now Croda International Limited) in order to manufacture high-grade gelatins and stearine from bones. Impulse-rendering is described³⁶ as "a mechanical rupture of the membranes of the fat-containing cells by a series of high-speed impulses transmitted through the medium of a liquid, whereby the fat in the cells is liberated and is removed by the liquid in violent movement". The impulse-renderer is in fact a flooded hammer-mill³⁷. With oilseeds it was found that under the conditions which prevail in the mill, the soluble proteins are associated with part of the lipid, and that subsequent centrifugation yielded three fractions: free oil, a meal containing fibrous matter, and a lipid-protein complex³⁸. With coconut, the fresh kernels are fed into the hammer-mill with ten times their weight of 0.15 per cent sodium hydroxide solution. The fibre fraction is then removed on a vibrating screen and the emulsion which passes through the screen is centrifuged to separate the free oil from the "lipid-protein complex". (Typical recoveries from this process are given in Table 6, and the product composition in Table 7.)

(b) The Robledano-Luzuriage process – for the flow diagram see Figure 2.

This process³⁹ was developed in the Philippines. Endeavours to improve the quality of coconut oil, and the meal, by processing fresh nuts have repeatedly been made in the Philippines during the past forty years^{40 41 42 43}, and these efforts may be considered to be the forerunners of the Robledano-Luzuriage Process. The fresh coconut kernel is grated in a comminuter and then pressed – yielding about equal proportions of emulsion and cake⁴⁴. The cake is then pressed again, yielding more emulsion and a residue which is used as animal fodder. The emulsion is then passed through a three-phase separator and three fractions are obtained – an oil-rich phase (the “cream”), an aqueous phase (the “skim-milk”) and a small amount of solids (protein). The cream is subjected to enzymatic action under closely controlled conditions of temperature and pH. It then undergoes a “freeze-thaw” operation and the oil is recovered by means of a second centrifuge. The protein contained within the skim-milk phase is coagulated by the application of heat, filtered, and then dried to yield a protein concentrate.

(c) The ICAITI process – for the flow diagram see Figure 3.

This process⁴⁵ was developed by the Instituto Centro Americano de Investigacion y Tecnologia Industrial (ICAITI). It is intended as a general purpose process for the extraction of oil from vegetable materials having a high moisture content (i.e. over 20 per cent). The essential feature of the process is the production of an emulsion by the wet-milling of coconut in a rod mill. The emulsion is then heated, whereupon it separates into three phases: an aqueous phase which is discarded, a light phase and a cream phase. The latter are concentrated by means of an evaporator and a basket centrifuge respectively. The concentrates are then bulked and passed to a rotary drier where the oil and protein recoveries are effected⁴⁶. Work on this project was virtually suspended in 1969.

(d) The Krauss-Maffei/CFTRI process

This process was originated⁴⁷ by Krauss-Maffei AG, and then further developed by the Central Food Technological Research Institute of Mysore, India⁴⁸. In the original process (Fig 4), the coconuts are autoclaved, shelled and the meats cut up and passed through a roller mill followed by a hydraulic press. The emulsion obtained is centrifuged to yield a “cream” and a “skim-milk”. Further separation of the “cream” gives oil and an aqueous sludge which is recycled. The “skim-milk” can be further separated into an aqueous phase and a protein phase which is dried to yield high protein flour. The aqueous phase is evaporated to give a coconut “honey”. The modified process (Fig 5) is much more complex, yielding five usable product streams: oil, meal, “whey”, protein concentrate and “honey”.

The essential difference between the two is that the Mysore workers found that autoclaving the coconut led to coagulation of the protein within the kernel, making subsequent extraction more difficult^{1 20}. As with the Robledano-Luzuriage Process, the emulsion is produced by pressing the fresh kernel. Centrifugal action then separates the emulsion into a “skim-milk” phase, and a cream phase. The oil and the protein recoveries are effected by further centrifugation. A feature of these processes is the concentration of the aqueous phase (obtained from the “skim-milk”), to obtain a “honey” type product which might have commercial value²⁰.

(e) The Roxas process – for the flow diagram see Figure 6.

In this process, shredded coconut meat is pasteurized before passing to the expeller. According to the patent⁴⁹, the purpose of heating the shredded meat is twofold:

to destroy the bacteria, and to coagulate the protein (it is claimed that coagulation of the proteins by this method decreases their emulsifying properties and thus renders subsequent separation of the emulsion into its components easier). The emulsion then undergoes a "freeze-thaw" operation and passes thence to a centrifuge. The recovery of the oil and protein is then effected in a manner similar to that of the Robledano-Luzuriaga Process.

(f) **The Sugarman process** — for the flow diagram see Figure 7.

This process⁵⁰, developed by the Georgia Technological Research Institute, Atlanta, USA, is said to be equally applicable to all oilseeds.

The fresh coconut kernel is first reduced in size in a grinding or flaking mill. In this step (batch-grinding) the material is reduced to the consistency of peanut butter. The ground coconut is next transported to a pebble mill where it is mixed with twice its weight of dilute alkali. The slurry is milled for three hours, transferred to a heated mixing tank where more water is added, and is then agitated for one hour. The slurry is separated in a three-phase separator to obtain a meal, "skim-milk", and "cream".

The concentrated oil emulsion ("cream") is broken by: pH adjustment, followed by colloid milling and, finally, centrifugation to recover the oil. It is claimed that the high shear forces generated by the colloid-milling of the cream break down the oil globules rendering the subsequent centrifugation simpler than if the cream were passed straight to the centrifuge from the pH adjustment stage.

The skim-milk phase is treated with acid to precipitate the protein which is then filtered, washed and dried.

MINOR WET-PROCESSES

Five other wet-processes for the extraction of protein and oil from fresh coconuts, developed by Alexander⁵¹, Gonzaga⁵², Cruz-Bernardo⁵³, Birosel⁵⁴ and the Protein Campaigne⁵⁵, are worthy of mention. However, none has received support in terms of further development in any of the major coconut-producing areas and, as such, can be considered only of minor importance.

WET-COCONUT PROCESSES: GENERAL OBSERVATIONS

To date, none of these processes is in commercial use. The principal reason for this appears to be that the yield of oil from the wet-processes, is 10–15 per cent lower than the yield of oil obtained from the processing of copra. It has already been pointed out in the Introduction that losses of up to 30 per cent occur by the copra process. Table 13 compares the yield and also indicates the true yields of oil extracted, starting from fresh coconuts to obtain refined oil.)

From this table it is clear that, in terms of yields of oil per unit weight of fresh nuts, the wet-processing techniques compare favourably with the more traditional method of oil extraction.

Further, the average dietaries in the coconut-producing countries are deficient in protein and it is important to direct attention to processes which extract protein fit for human consumption.

It is regretted that there is no published information on the capital and working costs of the wet-processes described above, however, due to the precarious economic situation prevalent in the coconut industry it becomes obvious that these costs have to be minimal. Thus, whilst there can be little doubt as to the technical feasibilities of the previously described wet-processes it is suggested that they are all encumbered with the following drawbacks in relation to the quantity of coconut processed:

- (i) Use of high capital cost machinery
- (ii) High energy requirements

It has already been pointed out that oil yields obtainable by wet-processing techniques are only apparently lower than those from copra, but, in fact, can be similar if not better in terms of overall oil yields from freshly harvested coconuts. ✓

It should also be noted that at least part of the cause of the economic failure of the modern wet processes must be attributed to the kinds of milling systems used. Those processes, which employ mills incapable of grinding the coconut to sub-cellular dimensions, will not achieve high extractions of oil and protein (see the discussion of TPI work).

Other processes

There remain three other processes for the extraction of oil and protein from fresh coconut. In each case the end product is a high protein coconut flour rather than a protein concentrate.

(a) The Hiller process — for the flow diagram see Figure 8.

The coconut is first cooked²⁰ to facilitate removal of the kernel from the shell. The kernel is then sliced and rapidly dried under vacuum — after which it is processed in a conventional expeller. The meal from the expeller is then finely ground to produce the coconut flour. A typical analysis of this flour is tabulated (Table 12) on the flow diagram.

(b) The azeotropic extraction process — for the flow diagram see Figure 9.

The milled coconut is subjected to an extraction with an azeotropic system based upon water and a solvent²⁰. The azeotrope should boil at below 120°C; the hydrocarbons (hexane, benzene) and chlorinated (trichloroethylene) solvents are considered suitable. When the extraction is complete and the coconut is oil and moisture free, it is passed through a micro-atomizer to produce coconut flour.

(c) The integrated coconut process — for the flow diagram see Figure 10.

The term “integrated” is applied to this process because it deals with the husk and shell, as well as with the meat of the coconut in processes carried out on one site. The intermediary product is in the form of granules and it is claimed that the production of these granules offers savings in time and money when compared to the production of copra⁵⁶. However, reliable cost figures are not available³³.

Discussion of experimental work carried out at TPI

THE COCONUT KERNEL

The starting point of this study was an investigation into the basic structure of the kernel. It was considered that an insight into future processing problems would be gained if it was first known, exactly how, and where, the protein and the oil were located in the coconut endosperm. With this in view, and using both the series of photomicrographs produced by Manzanilla⁵⁷ and at the TPI, the following observations were made:

- (a) The endosperm is comprised of many thousands of 'cylindrical' (parenchyma) cells oriented so that their 'long' walls are perpendicular to the outer wall of the kernel (Figure 13). These cells are compressed together compactly to produce an hexagonal structure (end view).
- (b) There is a graduation of cell sizes (the smallest cells occurring nearest the outer wall of the kernel) which ranges from 15 – 80 microns (average 58 microns) for the cell diameter, and 70 – 700 microns (average 340 microns) for the cell length.
- (c) The oil is contained in the cells in the form of discrete globules (Figure 13) – it would appear that there is a concentration of oil towards the outer wall of the kernel.
- (d) Generally protein is integral to the cell and is found in many of the cell's component parts – however it is probable that most of the protein is located in the cytoplasm in the form of a colloidal suspension. /

Table 4 shows that the endosperm can contain up to ten per cent of carbohydrates. Analysis has revealed that approximately 50 per cent of this is cellulose, and that up to 75 per cent of the cellulose is α – cellulose⁵⁸. The α – cellulose has a commercial value as a base material for the production of nitrates and/or acetates. It has already been stated that copra meal is an important source of animal feed both in the coconut producing countries and in those countries importing copra – thus if the coconut is to be exploited not only for its oil and protein, but also for its α – cellulose content, then it would seem that a new source of fodder for livestock would also have to be found.

EMULSION FORMATION: THE WET-MILLING OPERATION

In the Introduction it was noted that all the wet processes have two common features – firstly, the production of an emulsion and, secondly, the subsequent 'breaking' of this emulsion to recover the oil and the protein. The importance of the wet-milling operation lies in its relation to the overall yields obtainable from any process, since it is at this stage that the oil and protein are extracted from the coconut kernel. However very little data is recorded in the literature on the parameters which govern optimum extraction of the oil and protein from the kernel

by wet-milling systems using water in the continuous carrier medium. The objective therefore, of the milling experiments, was to identify these optimum extraction conditions.

The variables thought most likely to affect the extraction of the oil and protein were:

- (a) The type of mill used in the milling operation.
- (b) The feedstock.
- (c) The treatment undergone by the cellulosic residue obtained from the milling operation.
- (d) The water/coconut ratio.
- (e) The processing temperature.
- (f) pH
- (g) The feed rate.
- (h) The protein classification.

Regarding these variables, the fundamental question which had to be answered concerned the nature of the extraction mechanism: was the extraction of the oil and/or the protein principally dependent upon the parameters which govern the mass-transfer type of operation eg of the leaching or solvent extraction type; or was it more dependent upon the percentage cell rupture effected by the milling system? If it was the former, then the overall oil and protein extractions obtained would be most affected by altering variables (d), (e), (f), (g) and possibly (h); if the latter, then the significant variables would be (a), (b) and (c).

A summarised account of these variables with regard to the work carried out by the TPI now follows:

(a) The type of mill

The types of mill investigated were selected on the basis of their essentially differing milling actions, and were: a stainless steel rod-mill, charged with stainless steel rods; a wedge/die plate mill consisting of a knife-edged wedge rotating above a die-plate; a colloid-mill consisting of carborundum stator and rotor; and a swing-hammer mill. In each case an aqueous slurry of minced coconut kernel was fed through the mill and, after separation of the emulsion from the cellulosic residue, oil and protein yield data obtained. The operation of the mills were optimised by altering the operating variables associated with the individual mill.

Apart from its performance as regards oil and protein, a milling system suitable for the wet-processing of coconut should also be able to meet the economic criteria of low capital and operating costs, coupled with a high throughput of feed material – this, because the brunt of the economic justification of any wet-process has to be borne by the financial returns obtained from the selling of the oil, which is a comparatively low value product. Because of its low cost/performance ratio in comparison with the other mills, and also because the emulsions produced by the rod-mill were contaminated with metallic particles (differential body and rod wear is characteristic of this type of mill⁵⁹, the rod-mill was not considered to be a suitable item of plant for the milling of fresh coconut. Another point which was later shown to be important, was that the rod-mill could not wet-mill the coconut to the desired particle sizes.

Under optimised milling conditions, the oil and protein extractions obtainable from the other milling systems were similar (around 85 per cent) and thus the final choice of the mill depended upon their respective capital and operating costs. For

identical throughputs, the capital cost of the wedge/die-plate mill was approximately one fifth that of the other two mills. Accordingly the wedge/die-plate mill was adopted as being the most suitable unit for the wet milling system.

(b) The Feedstock

There were two considerations to be taken into account — the origin, and the feed size of the kernel to be milled. With regard to the former, the coconuts used in the milling experiments were, in the first instance, drawn from a single shipment from Dominica in the West Indies. This was done in order to minimise the possible effects of differences of age, origin, and variety, on the milling results. However, subsequent experimental yield data obtained from coconuts imported from Malaya, Jamaica and Ceylon did not give results which differed appreciably from those obtained using the Dominican coconuts. Thus variety and origin would not appear to be major factors in the efficiency of extraction of oil and protein.

With regard to the feed size of the coconut, three feed sizes were investigated. The feed material used in the milling experiments was drawn from fresh coconuts which had been previously minced through the wedge/die-plate mill. The three feed sizes investigated were obtained by using three different sizes of die-plate in the wedge/die-plate mill — namely the 5mm; 2mm; and the 1mm die-plate. A classification of these three feed sizes is given in Table 14 — the percentages refer to the % amounts retained on a particular size of sieve. From Table 14 it can be seen that the particle size distribution of the three feeds were substantially different: this proved to be an important point since it was demonstrated that the smallest sizes of feed material were associated with the highest oil and protein extractions; the converse was also found to be true.

(c) Treatment of the cellulosic residue

Slurries are often encountered in the fruit and vegetable processing industries. Frequently the solids (fibrous, or cellulosic) have to be removed from the liquids which are usually the desired products. Methods commonly employed for this type of solid-liquid separation involve, either the use of a basket centrifuge (batch or continuous), or a sieve and press operation. Accordingly, it was decided to investigate briefly the possibility of using one of these methods for the treatment of the cellulosic residue obtained after the coconut kernel had passed through the wet-milling system.

The mill used in this investigation was the wedge/die-plate mill; the press, a manually operated press manufactured by Tangye of Birmingham Ltd, and the basket centrifuge was a MSE laboratory model.

The milled coconut residue was subjected to four different treatments:—

- (1) Residue, basket centrifuged for five minutes at 5 000 rpm.
- (2) Residue, washed, and then basket centrifuged for five minutes at 5 000 rpm.
- (3) Residue, pressed under a pressure of approximately 1 750 psi.
- (4) Residue, washed and then pressed using a pressure of approximately 1 750 psi.

Three sizes of die-plates were used during the milling operation — 2mm, 1.4mm and a 1.0mm die-plate.

The results of the experiments are shown in Table 15 — the percentage figures refer to the oil (dry basis), and the moisture content (MC) analysis of the final residues obtained from the various treatments.

Statistical analysis of the various treatments indicated that the highest overall oil extraction was obtained when the cellulosic residue was subjected to Treatment (4), hence the sieve-wash-press operation was adopted as standard procedure for the process.

Experimental work on the residue was concluded following determination of its basic drying characteristics (Figure 15). The drying experiments showed that drying of the residue should be carried out at a temperature lying between the range 100–150°C, since the residue tends to smoulder and/or ignite at higher temperatures. It is suggested that the residue be dried in a dryer fired by combustion of the coconut shells, as this would provide a partial solution to the problem of useful disposal of the shells, assuming that no ready market already exists.

Finally, regarding the residue, there are at least three possible ways in which it could be utilised:—

- (i) As an ingredient for composite animal feeding stuffs.
- (ii) As a raw material source for an existing oil extraction plant. If this outlet could be developed, the financial returns obtained could be greater than that obtained from (i) — for although its oil content is approximately half that of copra, it is in a form most suitable for use in a solvent extraction plant, and, if properly blended with the milled copra, could also be used in the expression process. The selling price should be directly related to its oil content.
- (iii) It could be recycled back into the wet-milling system (in which case, it would not be previously dried), however it is doubtful whether any increase in the overall oil extraction achieved would justify the incremental costs thereby sustained.

(d) The water/coconut ratio used in the milling operation

It is well known that the physical properties of the suspending medium can play a considerable part in the wet-grinding of materials. Further, at the start of this investigation, the nature of the oil (and protein) extraction mechanism was not known, and thus it seemed possible that it could be in part, a leaching process — if it was, then dynamic equilibrium relationships would exist between the oil and protein remaining in the milled kernel, and that which had been extracted into the water. However, variation of the water/coconut ratio between the range 1:1 to 20:1, did not reveal any significant differences in terms of the oil and protein extractions achieved.

(e) The processing temperature

The temperature of the milling operation was varied between 30–85°C. The lower temperature limit was chosen so as to be sufficiently above the melting point range of coconut fat (19–25°C), and the upper limit (85°C) established to try to minimise denaturative, and coagulative effects on the protein.

Variation of the milling temperature did not prove to have any significant effect on the overall oil and protein extractions achieved.

(f) The pH of the milling operation

It had previously been shown, that the optimum conditions for protein extraction occurred in the pH region 6.0–8.0⁶⁰ maximum extraction being achieved at pH 6.6. Since the pH of the emulsions produced during the course of the present

investigation was in the range pH 5.8 to pH 7.0, it was decided that little would be gained by artificially changing the pH of the system by the addition of buffers. However, this is not to discount the possible value of utilising deliberate variation of the pH as a means of selectively extracting specific proteins from the kernel — indeed, it may well be that such a technique would produce an emulsion exhibiting entirely different properties from those produced at the TPI.

With regard to the extraction of the oil, it is doubtful whether pH has any major effect, although it is possible that if very alkaline milling conditions were used, some saponification of the oil would result.

(g) The feed rate

The three mills used in the experiments were of the short-residence-time type, flow rates into and out of the mills being determined by the internal mill settings — that is, for the hammer-mill, colloid-mill, and wedge/die-plate mill, the flow rates are respectively determined by the diameter of the screen holes, the clearance between the grinding discs, and the diameter of the die-plate holes respectively. The settings used on the hammer and colloid mills, were such as to give similar flow rates. The same flow rate of the feed material was used for the wedge/die-plate mill, but whereas the other two mills were working at maximum capacity for their particular settings (ie flood feed conditions), the wedge/die-plate mill (being a production plant machine) was only running at a fraction of its capacity.

(h) The protein classification (Osborne⁶² Classification)

The possible importance of this factor primarily concerns the extraction of the protein, and pertains to the solubility of the proteins under different conditions. During recent years, it has become apparent that a single protein could be classified in two or more ways, depending on the method used for its isolation¹⁸. Also, so many proteins have been found that seem to lie in between two types, that the solubility classification⁶¹ is today given less and less attention. Nevertheless, group names like albumin, globulin, gelatin etc, still appear in the literature, and it is for this reason that the solubility classification, together with the possible processing applications is now discussed below.

With regard to the oilseeds generally, Bondi¹⁸ states that the main and most characteristic fraction of proteins contained therein, are the globulins, which can comprise up to 80% of the total protein content. Finks and Carsdoff⁶³, reported that the principal protein of the coconut endosperm is a globulin.

However, Ito⁶⁴ found that of the protein contained in coconut meal, 23–25% was water soluble, 10–13% was soluble in salt solution, 10% was soluble in 70% ethyl alcohol, and 40–47% was soluble in dilute alkali. Cater⁶⁵ reports the classification of the proteins in coconut meal as follows: albumin 30.6%; globulin 61.9%; prolamin 1.1%; and glutelin 4.7%.

At first sight, the differences between these results is somewhat confusing, however, there can be little doubt that the solubility of the coconut protein will depend upon the manner in which it is isolated, and will vary accordingly. For example, it has been shown⁶⁶, that the solubility characteristics of the proteins in their isolated form, differ to a remarkable degree from that of the proteins contained in the seeds.

As to the possible plant applications of selective protein extraction — it is very doubtful whether use of the various solvents to extract the protein from coconut could be economically justified; perhaps this type of procedure would be viable in

large capacity plants. Since the overall objective was to develop, in the first instance, a process capable of dealing with around three tons of fresh kernel per working day, it was not felt that examination of the solubility characteristics of the coconut protein would be a fruitful area of investigation. The basic concept adhered to was to prepare a protein isolate by using minimum quantities of heat, chemicals etc, to keep modification of the protein as low as possible, and thus help to retain the overall nutritional quality and any functional properties of the protein.

The Wet-Milling of Coconut Kernel:

Conclusions

The objective of the wet-milling experiments was to identify the conditions necessary for optimum extraction of the oil and protein from fresh coconut. The fundamental question which it was considered necessary to answer, concerned the nature of the extraction mechanism ie was the extraction of the oil and/or the protein primarily dependent on mass-transfer parameters, or was it more dependent upon the percentage cell-rupture effected by the milling system? The evidence as given by statistical analysis of the experimental results, supports the cell-rupture theory.

The evidence may be summarised as follows:—

- (i) The fact that variation of the temperature and the water-to-coconut ratio used in the milling operation does not significantly affect the subsequent extractions of the oil and the protein.
- (ii) The fact that the highest extractions were obtained with the smallest feed sizes — the significant point here is that the smaller the feed-size, the greater the proportion of coconut already ground to sub-cellular dimensions.
- (iii) The strong correlation between the particle sizes of the residue and the oil extraction. The oil extraction was found to be directly proportional to that part of the residue lying within the sub-cellular range — and the greater this percentage, the higher the oil extraction (Figure 16).
- (iv) The overall per cent extractions of the protein and oil were found to be similar, no significant differences occurred between the percentage protein extracted and the percentage oil extracted from the same milling operation.

Coconut emulsion

Though little is known of the nature of coconut emulsion systems, parallels can reasonably be drawn with similar emulsions containing oil and water, stabilised by proteins eg the extensive research which has been carried out in the dairy industry on the nature of the milk-fat-globule membrane within the milk emulsion system.

Coconut emulsion is a dispersion of one liquid (oil) in another (protein solution) — the oil droplets being surrounded by a film of interfacially active protein. The dispersion of one fluid phase into a second fluid phase, under fixed mechanical conditions, will be favoured by a low interfacial tension — the presence of a surface-active-agent (protein, in the case of coconut emulsion) will serve to promote this effect through one, or both of the following quite distinct phenomena:—

- (1) A lowering of the boundary tension prevailing at the interfaces.
- (2) A stabilisation of the interface by the formation of adsorbed layers which mechanically oppose any tendency for these interfaces to be diminished or destroyed.

The first of these two effects makes easier the initial process of mechanical subdivision, and reduces the degree of thermodynamic instability; the second, stabilises the emulsion — this stabilisation may also increase the efficiency of the preceding stage by reducing coalescence⁶⁷. The stability arising from the second of these two effects can surpass the stability resulting from the first — the emulsion stability in the case of the second effect being a function of the mechanical strength of the adsorbed protein film⁶⁸.

With regard to the structure of the film enclosing — globules — the bulk of the existing literature on protein adsorption at interfaces (oil/aqueous protein solutions), assumes the presence of a protein monolayer in which the molecules of the protein are oriented in such a way that the polar heads penetrate the aqueous solution, while the non-polar groups are immersed in the oil phase. However, coconut oil is slightly polar, and for these systems it is thought that the film has a multi-layer structure⁶⁹.

The films themselves will be principally composed of proteins, but phospholipids and other film-forming substances may also be present. Finally, due to the multiplicity of the hydrophobic and hydrophilic groups available for adsorption/attachment at the oil/water interface, the emulsion can be expected to be very stable.

'Creaming' of the emulsion

After due consideration of the various factors involved, it was decided first to coagulate the emulsion at the iso-electric point of the protein (around pH 4), and then to centrifuge the resultant 'cream'. Experiments were carried out using acids

of differing strengths, in order to compare and contrast their relative merits as the agent to be used for this pH adjustment operation (Figure 17). The restrictions imposed on this agent were as follows:

- (1) It would have to be an accepted food additive (designated as GRAS in Food Legislation) – this due to probable interaction of the acid with the protein, and possible reaction with the oil.
- (2) The acid would have to be readily available in coconut producing areas.
- (3) The acid should be able to suppress the growth of micro-organisms on the emulsion substrate. (It had previously been demonstrated that if the emulsion was not treated with an antimicrobial agent, it fermented, following a typical acid-type fermentation path). In the event, acetic acid was shown to be suitable, and it was decided to use this acid for the pH adjustment operation.

The advantages of precipitation at the iso-electric point are that denaturation of the protein is minimised and also, since the solubility of protein is very low at its iso-electric point, losses in the aqueous phase are nominal and thus maximum recovery into the cream phase is effected. Cater⁶⁵ has indicated that only 2.5 per cent of coconut protein is soluble in the pH range 3.4 to 4.0.

If, after the pH adjustment, the emulsion is left to cream for 24 hours, the cream phase will then only constitute between 20 to 25 per cent by volume of the original emulsion. Thus, a substantial reduction in bulk handling and centrifugation costs is achieved.

Previous studies⁶⁰ have shown that the iso-electric point for coconut protein lies between pH 3.4 to pH 4.0.

By taking samples of emulsion, adjusting the pH to level in the range 3.0 and 10.0, and allowing the sample to 'cream' at constant temperature, it was found that optimum creaming occurred at pH 3.5 to pH 4.0. It was also found that the creaming operation seems to follow the induction – free settlement – compaction pattern, often found in sedimentation, or flocculation processes. However, despite these similarities, the coagulated emulsions differed quite considerably in their physical appearances particularly in the clarity of the respective aqueous phases. The clearest aqueous phases were found in the acid precipitated systems: pH 3.5 having a transparent aqueous phase, with no visible particulate matter held in suspension – pH 3.0 and 4.0 also had transparent aqueous phases, but both contained small amounts of unidentified suspended material – pH 5.0 gave an aqueous phase which was slightly 'cloudy' in appearance. The aqueous phases of the emulsions adjusted with alkali were opaque. The nitrogen content of these aqueous phases was too low to be assayed by Kjeldahl detection of residue left after evaporation of the water.

The principal variables found to govern the rates of 'creaming' were, emulsion composition, adjusted pH level, temperature; and of these, the level to which the pH of the system was adjusted appeared to have the greatest influence, followed by temperature, and emulsion composition respectively. Generally, emulsions acidified to within the pH range 3.5–4.0 creamed most rapidly, the initial rate of emulsion creaming also increased with temperature. The degree of aeration to which the emulsion had been subject also affected the initial creaming rate – the more air, the quicker the rate.

However, although the initial creaming rate could be increased by altering the parameters discussed above, the final volume resolution (cream and aqueous phases) achieved by emulsions of similar composition (with the exception of aerated emulsions) were similar (Figures 18a and 18b), and it is considered therefore that no useful purpose can be served by artificially altering these parameters.

As a result of our experimental observations and taking into account those of Sison⁶⁰, it was decided that the bulk emulsion should undergo the following treat-

ment before the centrifugation operation: (1) pH adjustment to within the range pH 3.5 to pH 4.0. (2) be allowed to 'cream' for at least eight hours. (3) the aqueous phase then to be separated from the concentrated emulsion (cream) by running at either totally, or partly, to drain, depending upon local sewage disposal facilities.

If it is necessary to minimise the load on the available sewage system, then it has been shown that the aqueous phase can be recycled back into the process without radically altering it. Recycling the aqueous phase (acidic) does not reduce the total quantity of acetic acid needed for the pH adjustment operation. The reason for this, would seem to be that the emulsion system appears to 'buffer' within the iso-electric range (pH 3.5–pH 4.0) of the protein (Figure 19).

The major result of recycling the aqueous phase is the subsequent increase in creaming vessel storage capacity (costs) required. Whether the aqueous phase is recycled, or run to drain, the important feature of this part of the process is to separate the emulsion from the cream phase in order to facilitate centrifugation of the cream.

The 'creaming' refers to the induced coagulation step. It is appreciated that this does not in itself constitute a creaming process – however, it is true to say that despite the various mathematical models which have been developed to describe the phenomenon⁷⁰, the creaming process is not well understood.

Coconut emulsion which has not been treated with acid or alkali, does, in fact cream – two phases being clearly visible. According to the criteria of Griffin⁷¹ when two phases can be distinguished in an emulsion, the presence of macro-globules is indicated.

Photomicrographs of the 'cream' show that, as with cow's milk, it would appear that the natural coconut emulsion tends to cream in 'clumps' of globules (with cow's milk, it is thought that creaming is governed by Stoke's Law considerations – large globules rise faster than small ones, collide with them, form clusters and hence creaming rate increases).

Analysis of experimental results showed that the creaming process followed a simple equation:

$$\log\left(\frac{H-H_t}{t}\right) = \log C - m \log t$$

- where t is period of creaming
- H is final level achieved by the protein/cream layer
- Ht is lower level of the cream layer at time t
- C and m are constants characteristic of the emulsion

Physical properties of the cream phase

(a) Emulsion type

Using the methods first described by Hauser and Lynn⁷², and regardless of the method of preparation, or subsequent treatment, the creams were found to be oil in water emulsions.

(b) Composition

The composition varied according to pH and period of creaming. Generally the highest oil levels, and lowest moisture contents, were associated with the longest creaming periods and vice versa. For similar periods of creaming the pH region 3.0 to 4.0 gave creams with the highest oil content.

The percentage composition (Wt/Wt) of creams formed at pH 4.0 varied as follows:

Water : 65% – 78%

Oil : 20% – 30%

Solids : 1% – 4%

(c) *Physical properties*

(1) Density of Creams: 0.95gms/cc – 1.0gms/cc (pH 4.0)

(2) Specific heat of creams: 0.78cals/(gm)[°]C – 0.85cals/(gm)[°]C (pH 4.0)

(3) Viscosity by Torsion Viscometer at 50°C: pH 3.5 – 0.84cp

pH 4.0 – 0.90cp

pH 4.5 – 0.88cp

(d) *Globule size distribution*

The size distribution of the oil globules contained in the pH 4.0 cream was determined by taking measurements from enlarged photomicrographs of the cream.

Although the range of diameter is wide (0 to 35 μ), for the majority of globules it was below 5 μ (Figure 20) giving a very sharp peak on the distribution plot of frequency of occurrence against diameter. The small globule size undoubtedly affects the centrifugation of the cream.

Centrifugation of Coconut Emulsion

Some of the more common methods which have been used to break coconut emulsion have already been mentioned in the Review Section. Most of the more common methods for breaking emulsions (eg the application of heat, chemicals, or enzymatic degradation techniques) if used on the coconut emulsion, would lower the quality of protein and possibly of oil. With this in mind, it was decided to investigate the possibility of using centrifugal force — a purely physical phenomenon — to break the emulsion.

The studies on centrifugation of the emulsion (acidified cream) began with the use of laboratory centrifuges (bottle, and solid-bowl disc centrifuges); progressed to experimentation with pilot-plant self-cleaning centrifuges (nozzle and hydraulic discharge); and concluded with trials on a full plant sized three phase separator.

Experiments were carried out to determine the behaviour of the emulsion when subjected to centrifugal forces, under varying conditions of emulsion temperature, and period of centrifugation (bowl residence time). From Figure 21 it can be seen that the emulsion appears to resolve into four quite distinct phases when centrifuged — a free oil phase, an interfacial protein phase, an aqueous phase, and another* protein phase. The interesting aspect of this resolution is the presence of the interfacial protein — density determinations on the various phases showed that it did not have a density intermediate between that of the oil and the water, but that its density was similar to that of the lower protein phase — clearly therefore, its positioning is not due to a simple density gradient. Further, it is worthwhile noting that standard tests for lipo-proteins proved negative when applied to the interfacial protein phase.

As a result of these investigations, the authors suggest that a possible explanation for the presence of the interfacial protein lies in a consideration of the relative migration of oil globules under the action of centrifugal forces, coupled with the absolute sizes of the oil globules contained within the emulsion. It was shown experimentally that the length of time for which the emulsion is centrifuged, has an important bearing on the relative proportions of the two 'different' protein fractions obtained (Figure 22), and that the weight ratio (interfacial protein phase : lower protein phase) decreased with increased centrifugation time (Figure 23). The logarithmic nature of these relationships leads the authors to suggest that they are governed by the size distribution of the oil globules contained in the emulsion. It is suggested that, apart from Stoke's Law considerations, the smaller oil globules, because of their relatively high surface tension, will require more work to be done on them to rupture their enclosing protein membranes, than the larger globules: they will need a longer period of centrifugation in order to appear in the oil phase.

The experimental data illustrated in Figures 22 and 23, were obtained following the use of the bottle-centrifuge. The graph shows that the emulsion required a

*Included within this phase are coconut testa particles.

centrifugation period of approximately thirty minutes in order to effect an acceptable phase resolution. Regarding centrifugation generally, common industrial practice is to use the bottle-centrifuge to determine sedimentation characteristics of liquid mixtures and/or suspensions. Mixtures/suspensions thought of as having 'ideal' centrifugation characteristics will normally resolve in five to ten minutes. Thus it can be seen that coconut emulsion does not exhibit very favourable centrifugation behaviour. These observations suggested that a single three phase (liquid-liquid-solid) self cleaning separator would not be able to effect efficient resolution of the coconut emulsion into its constituent phases of oil, water and protein, due to insufficient liquid residence time within the bowl of the centrifuge. Subsequent experimental trials, using continuous centrifuges of the nozzle and hydraulic discharge types, confirmed this view, as they were not able satisfactorily to separate the emulsion into its distinct phases of oil-water and protein.

Although our results suggest that 'normal' plant 3-phase separators will not be suitable emulsion 'breaking' machines, it is possible, that those centrifuges offering all the desirable criteria of high speed centrifugation — eg very high 'g' forces, and large disc diameter, will be able to bring about good phase resolution of coconut emulsion. However, due to the excessively high capital, and operating costs of these machines, relative to the value of the coconut products, it is doubtful that they would prove to be an economically viable proposition.

Another alternative, and the solution adopted by the TPI is to use one or two, solid bowl disc centrifuges (run batchwise) not of the self-cleaning type, to break the emulsion. These centrifuges allow establishment of phase resolution on the disc stack, and within the bowl, thus giving sufficient liquid residence time within the centrifuge and achieving the desired separation. They also have an additional practical advantage in that they are much less expensive than the self-cleaning machines.

A disadvantage* in the use of this technique, is that the centrifuge(s) have to be shut down periodically for removal and subsequent processing, of the protein cake collected on the bowl periphery.

Centrifuge bowl solids — This is the protein cake referred to above. Its composition is given in Table 16.

In order to facilitate removal of the oil by solvent extraction, the protein cake was first dried to approximately five per cent using a vacuum oven. The drying curves obtained are shown in Figure 24. The suggested process drying temperature to be used should be between 55–80°C in order to minimise possible nutritional damage to the protein.

The dry protein cake was subsequently solvent extracted using iso-propanol. The defatted protein solids were then vacuum dried at 60°C for one hour to remove traces of solvent, and finally milled to a fine powder using a hammer mill. Depending upon whether pared, or unpared coconuts were used as the feedstock to the process, the final appearance of the protein isolate was white or brown. It has been shown that the brown colour is mainly caused by the polyphenolic pigments present in the testa.

*It is possible that this problem could be overcome by running two centrifuges in sequence. The first centrifuge to be operated as a self clearing clarifier, and the second centrifuge as a separator.

Properties of the products

Properties of the oil

The oil was tested using the standard methods⁷³. The results obtained are shown in Table 17, together with various standard specifications for refined and unrefined coconut oils. It can be seen that the quality of the TPI oil is extremely good, being considerably better than that of the unrefined oils and almost matching the specifications for the top grades of the refined oils. Thus it seems possible that the oil made by the process outlined would warrant a premium price in the coconut oil market.

Typical food uses for the oil range from the highly refined oils used in the manufacture of margarine down to the less refined oils used for cooking purposes, shortenings and confectioner's fats. The major non-food markets include extensive use in the manufacture of cosmetics, soaps, glycerol and synthetic detergents.

Properties of the protein isolate

Aspects of the protein isolate which have been investigated are its basic composition (Table 19), its amino-acid composition (Table 18) and its use in the production of bread made from composite flours (page 29). As a result of these trials it was concluded that the bread produced from a wheat flour/cassava starch/coconut protein mix was comparable in quality to the standard loaf (bread produced from wheat flour only). Good loaves were obtained from flours consisting of six per cent (by weight) coconut protein, 30 per cent cassava starch and 64 per cent strong wheat flour (of 14 per cent protein content).

The importance of this result to the coconut process lies in the fact that a potential use for the protein has now been developed.

Decortication of coconuts

Coconuts, harvested from palms, are first dehusked, the shells cracked, and the kernels removed. These operations are carried out manually, the husk being detached by striking the coconut against a sharpened spike, and the shell cracked open by means of a machete. It is said that dehusking can be carried out at a rate lying between 1 000–2 000 coconuts per man day¹⁰, and the cracking and kernel removal operation at a rate of 2 000 coconuts per man day. Paring of the kernel is performed at a rate of 2 500 kernels pared per man day. In most of the coconut growing areas, labour is inexpensive and plentiful; however, there are areas where labour costs are rising rapidly, and it suggested that this trend is likely to continue, and indeed followed by all the coconut producing countries at some time in the future. It would seem desirable therefore to devise methods of decortication that are less labour intensive than those presently employed. Numerous patents exist which describe mechanical dehusking^{74 75 76}; cracking^{77 78 79}; and kernel and testa removal^{80 81 82}.

To date, mechanical decortication techniques have not been received with great enthusiasm (as evidenced by their almost total lack of use) in the coconut growing areas. It would appear that they do not compete, economically, with the more traditional methods: yields, be it of husk, or kernel, are generally lower than those achieved manually, and in an industry where profit margins are hard earned and relatively small, it is essential that wastage must be minimal. Automated decortication techniques, which do not match, or improve upon, yields presently achieved, are not likely to be adopted.

One of the difficulties encountered in decortication, is to be found in the actual removal of the kernel from its shell casing. The difficulty arises due to the firm attachment of the kernel to the inner shell. The process first patented by Hall and Banks⁸³, and currently in use by the TPI, consists of subjecting the dehusked coconut to hydraulic pressure, manages to destroy this attachment.

It has been found that when coconuts are treated in this way, the kernels become detached from the shell, thus facilitating the kernel removal operation. The principle of using hydraulic pressure as an aid to decortication can easily be adapted for use in the plant scale.

With regard to the dehusking of coconuts, the TPI have recently begun a development programme, which it is hoped will lead to the design of a competitive automatic, or semi-automatic dehusking method.

Outline of the TPI Wet-Coconut Process

The process devised as a result of the investigations into the problems involved in the extraction of oil and protein from fresh coconut, is schematically illustrated in the mass balance flow-diagram (Figure 11). The overall yields from the process are around 85 per cent for both the oil and the protein.

Fresh kernels are sliced, minced through the 5mm die plate of the first wedgemill, slurried with water (2:1, water:coconut), and the slurry milled through the 1mm plate assembly of the second wedge-mill. The resulting emulsion is passed through a vibrating sieve to remove the coconut residue: high velocity water sprays (placed directly above the sieve) ensure that the traces of oil and protein contained on the surface of the residue are washed through into the main emulsion. The residue is pressed to extract more emulsion, and the liquid pressings are then added to the main emulsion. The pressed residue is dried, and bagged, ready for use either as a constituent of livestock fodder, or, as a raw material source for a conventional oil extraction plant. A satisfactory continuous press has not yet been developed and work is continuing on this.

The pH of the emulsion is adjusted to within the range pH 3.5 to pH 4.0, and allowed to stand for a minimum period of eight hours. The acidified emulsion subsequently separates into two distinct phases — a lower aqueous phase, and an upper 'cream' phase. The aqueous phase is totally or, partially discarded and/or recycled, depending upon local sewage disposal requirements. The oil and protein are then recovered from the cream phase by centrifugation at a temperature of 35°C. Although it is probable that the oil obtained will require no further treatment to improve its quality, the protein solids deposited within the centrifuge bowl, still have to be freed from the oil contained within the mix. Accordingly, the protein solids are vacuum dried (29in.Hg) at a temperature lying between 55°C—80°C; and the oil extracted with iso-propanol. The defatted protein is then vacuum dried at 60°C for one hour to remove traces of solvent, after which it is milled to a powder. At this stage the protein isolate obtained is ready for use as a nutritional supplement.

Alternative Products

With few exceptions most developing countries consume a high proportion of the coconut crop, partly as industrially produced materials (oil and soap) but mainly as fresh coconuts, consumed domestically. Many peasants grow their coconuts mainly for this purpose: the emulsion is expressed by hand from grated flesh and is used in curries etc.

With the increase in urban population there has been an increasing demand for coconuts in the towns. In terms of emulsion obtained, transport costs are high. The urban housewife prefers convenience foods that require less preparation than traditional dishes. Hence there would seem to be a need for a pre-packed, ready-to-use coconut emulsion or 'cream'.

However, further work is needed to determine which products would prove most desirable to the consumer or to the export trade. The flexibility of the TPI process will prove an advantage where a manufacturer wishes to produce a variety of products depending on market demands.

In certain countries such products are already available in small quantities; they include for example, coconut 'milk' drinks, pasteurised emulsion, frozen emulsion, and blends of oil with cow's milk solids to form a pseudo-coconut cream. The 'milk' drinks are, of course, partly defatted emulsion preserved by pasteurisation or by addition of preservatives.

The TPI process was originally conceived as producing three products: oil, meal and protein. However, by using the emulsion as obtained from the sieve system and removing some of the oil by centrifugation, one can obtain a coconut 'milk'. This can be preserved by either (1) freezing, or (2) Pasteurisation* followed by homogenisation, using added emulsifiers and, if necessary, preservatives. If the emulsion is blended with oil using an emulsifier a coconut 'cream' is obtained which can be kept satisfactorily below 10°C.

The initial stage of the TPI process produces coconut meats in granular form — in fact the wedge/die-plate mill, as used in the first operation, can be used to produce granular coconut of various particle sizes, which, if dried, is similar to desiccated coconut.

It is thus possible to use the TPI coconut process to produce coconut 'milks' and 'creams' in addition to oil, meal, edible protein and desiccated coconut. Figure 12 shows some of these possibilities and a research programme has already been started.

*perhaps using UHT methods

Other oilseeds

Preliminary experiments with groundnuts indicate that, using the process outlined, a very high quality groundnut oil and a good grade of groundnut protein isolate can be obtained. Further work is being considered.

Suggested integrated scheme

Figure 13 shows a putative scheme for manufacture of a composite flour suitable for bread and baked goods manufacture, starting with coconut, cassava and wheat.

Bran from the wheat may be added to the animal feed which can be prepared from the wastes of the coconut and cassava processes.

Breadmaking with cassava starch and coconut protein isolate

by A. W. James

For nutritional studies bread was made using the following recipe:

	Per cent	
Canadian wheat flour (14.5% protein)	50	
Cassava starch	43.8	
Coconut protein concentrate (80% protein)	6.2	
Dried yeast	1.5	} calculated as a percentage of flour weight.
Salt	2.0	
Sugar	1.5	
Malt	0.4	
Fat	0.7	
Ascorbic acid	150 ppm	
Water	60	

PROCESS DETAILS

All doughs were mixed on a Morton Duplex Mixer according to the basic requirements of the Chorleywood Bread Process. The yeast used in our experiments was DCL Active dried yeast. This was reconstituted in a portion of the dough water and held at 38°C for 20 minutes with some of the sugar.

Dough mixing was carried out at 0.4 hp minutes per pound of dough. The doughs were then divided by hand and rounded-up, again by hand. The dough piece was then given ten minutes intermediate proof and the final mould (shaping) was through a Jecomolda. Final proof was given until the dough piece reached a height of 4.5 in. It was then baked at 235°C for 40 minutes.

Loaf volume was good and only slightly inferior to that of bread made by the same process and using 50 per cent cassava starch and 50 per cent wheat flour^{84 85}.

First indications from nutrition studies carried out by TPI Food Department are that the NPU of such bread compares very favourably with a standard wheat loaf.

Tables

Table 1

Coconut production

millions of nuts

Region/Year	1965	1966	1967	1968	1969
Latin America	2 103	2 257	2 327	2 241	2 197
Far East	22 482	22 850	22 400	23 468	24 377
Africa	1 289	1 307	1 397	1 394	1 438
Oceania	1 671	1 619	1 628	1 737	1 753
World Total	27 545	28 033	27 752	28 840	29 765

Table 2

Copra production

100s of metric tons

Region/Year	1965	1966	1967	1968	1969
Latin America	2 526	2 386	2 425	2 466	2 441
Far East	26 461	28 448	25 243	26 224	26 313
Africa	1 106	962	1 100	1 118	1 170
Oceania	2 837	2 705	2 710	2 926	3 041
World Total	32 930	34 501	31 478	32 734	32 965

Source: Ref. 100

Table 3

✓Composition of the coconut

	% age (wt)	TPI data
Shell	23.5 – 32.8	38.5
Kernel	48.2 – 62.0	51.7
Water	8.2 – 25.1	9.8

The coconut husk can constitute up to 35 per cent (wt) of the whole fruit.

Source: Refs. 20, 96, 101.

Table 4
Composition of kernel from mature coconuts

	% age (wt)	TPI data
Oil (wet basis)	35 – 40	38.1
Protein	4 – 5	3.6
Moisture	40 – 50	44.0
Carbohydrate	5 – 10	9.9
Crude fibre	2 – 4	3.1
Ash	1 – 1.5	1.3

Source: Refs. 8, 20, 95, 97, 98.

Table 5
Composition of copra and the press cake

% age composition (wt/wt)	copra	press-cake
Moisture	5 – 7	6 – 12
Crude protein (N x 6.25)	8 – 10	19 – 21
Oil	60 – 70	0 – 12
Crude fibre	4 – 5	10 – 20
Carbohydrate	10 – 13	35 – 45
Ash	1 – 2	5 – 8

Source: Refs. 7, 95.

Table 13
Oil yields: Copra versus the Wet-Coconut Process
Basis: 1 000 lb of fresh coconut of 37.5% oil content

Process	Copra				Wet Coconut	
% loss of original fruits	30%		20%		Nil	
Wt of oil available for extraction	262.5 lb		300 lb		375 lb	
% overall yield of oil	90%	95%	90%	95%	70%	80%
Wt of oil recovered	236.3 lb	249.4 lb	270 lb	285 lb	262.5 lb	300 lb

Table 14
Classification of the feed material sizes

B.S. Mesh Number	Diameter of die-plate holes		
	5.0mm	2.0mm	1.0mm
10(1 680m)	25.0%		
22(710m)	58.0%	59.0%	
30(500m)	11.0%	31.0%	58.0%
60(250m)	6.0%	10.0%	34.0%
60+			8.0% below 60 mesh

Table 15
Results of the residue treatments

Residue Treatment	Diameter of the die-plate holes					
	2.0mm		1.4mm		1.0mm	
	% rail (d.b.)	% MC	% oil (d.b.)	% MC	% oil (d.b.)	% MC
1	48.7	47.4	49.4	47.0	48.7	44.8
2	47.2	50.7	46.9	50.0	42.2	52.8
3	38.1	37.9	36.8	40.8	34.8	43.1
4	35.0	36.3	34.2	39.2	32.9	42.4

Table 16
Analysis of centrifuge bowl solids

Component	% (wt)
Oil	35.2
Moisture	41.2
Protein solids	23.6

Table 17
Coconut oil specifications

Property	Brit std spec for copra oil (unrefined)	Am std spec for copra oil (unrefined)	Oil obtained from TPI Process	Brit std spec for refined oil (edible oil)	Indian std spec for refined oil (edible oil)
Colour (Lovibond scale)	5 yellow 1.2 red		0.4 yellow 0.1 red	0.8 yellow 0.1 red	
Refractive Index (40° C)	1.4485–1.4492	1.448 – 1.45	1.4482		1.448–1.449
Iodine value	7.0 – 11.0	7.5–1.05	7.1	8.6	7.5 – 10.0
Saponification value	248 – 264	250 -- 264	257	257.3	250
Acid value	14.2		1.53	0.25	0.5
FFA	5%		0.4%	0.1%	0.18%
Unsaponifiable matter	0.8%	0.5%	0.04%	0.18%	0.5%
Reference	(90)	(1)	(102)	(91)	(1)

Table 18

Amino acid analysis of coconut protein

g Amino-acid per 16g N

No	TPI 1 isolate	TPI 2 isolate	TPI 3 isolate	Hopper 4 copra meal	Hopper 5 copra meal	Human Need (g)d 6
Lys	4.2	4.8	3.7	3.1	2.2	0.8
Phe.	4.9	5.7	5.3	5.1	3.9	1.1
Try	0.78	1.0	0.4	1.0	0.7	0.25
Meth	1.26	2.8	2.33	1.8	1.2	1.1
Isoleu	3.3	3.6	3.3	5.3	3.4	0.7
Leu	6.2	9.0	7.0	7.9	4.9	1.1
Thr	2.4	4.0	3.3	3.8	2.9	0.5
Val	4.9	5.8	4.9	4.8	6.1	0.8
Ala	3.8	5.0	4.0			
Arg	12.3	15.5	15.5	11.4	10.3	
Asp	8.4	11.5	9.2			
½Cys	0.72	1.86	1.0			
Glu	17.6	22.8	20.4			
Gly	3.5	5.39	4.1			
His	2.83	2.7	2.2			
Pro	2.6	4.2	3.7			
Ser	3.6	6.1	5.1			

Notes

Results for Nos 4 and 5 are from ref¹⁸ and are the upper and lower limits for the six samples quoted. 6 is quoted from ref⁹². It is worth noting that whilst the major portion of the nitrogen contained in the endosperm is in the form of protein, nitrogen is also found as free amino acids, glutamine, betaines, glutathione, and the simple peptides, which are present in small quantities⁹³. Coconut is said to contain between 0.4% and 1.5% non-protein nitrogen⁹⁴.

Figures

Figure 1
Flow diagram: the Chayen process

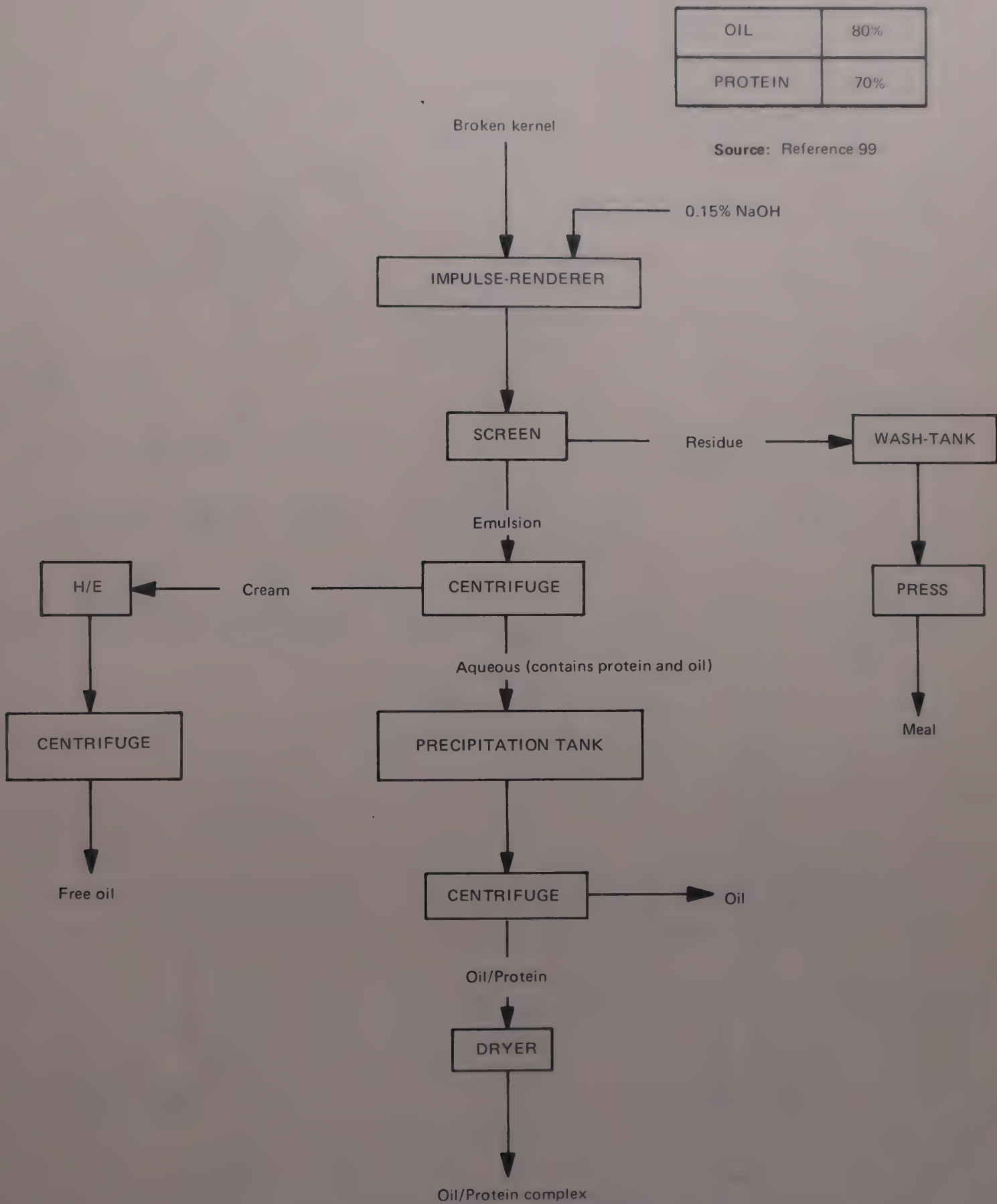


Table 6
Percentage oil and protein yields

OIL	80%
PROTEIN	70%

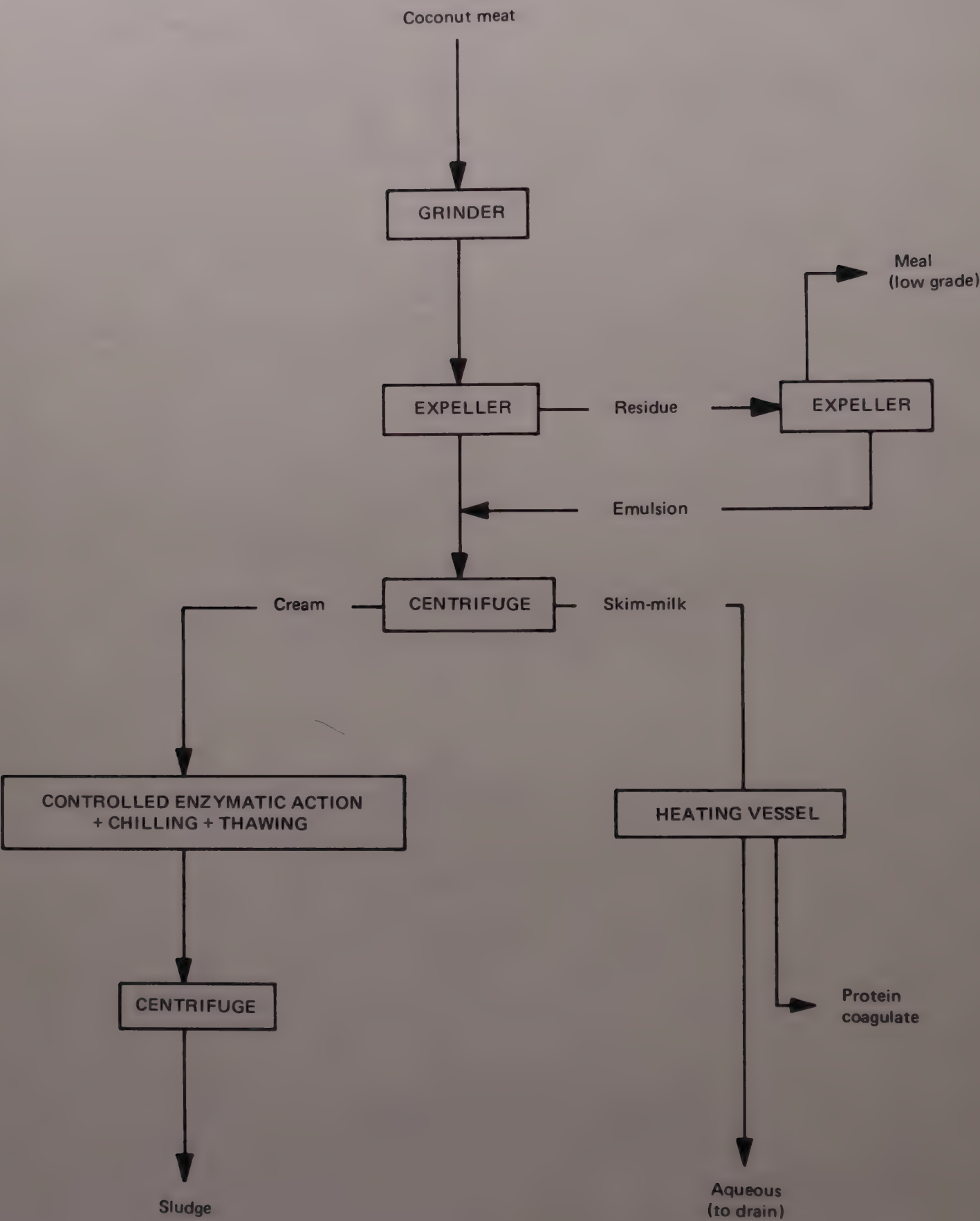
Source: Reference 99

Table 7
Product composition

	% OIL	% PROTEIN	% C-H	ASH	B.V.	N.P.U.	D.
OIL/PROTEIN COMPLEX	35	60	2.5	2.5	60	50	75%
MEAL	20	1.5	75	3.3			

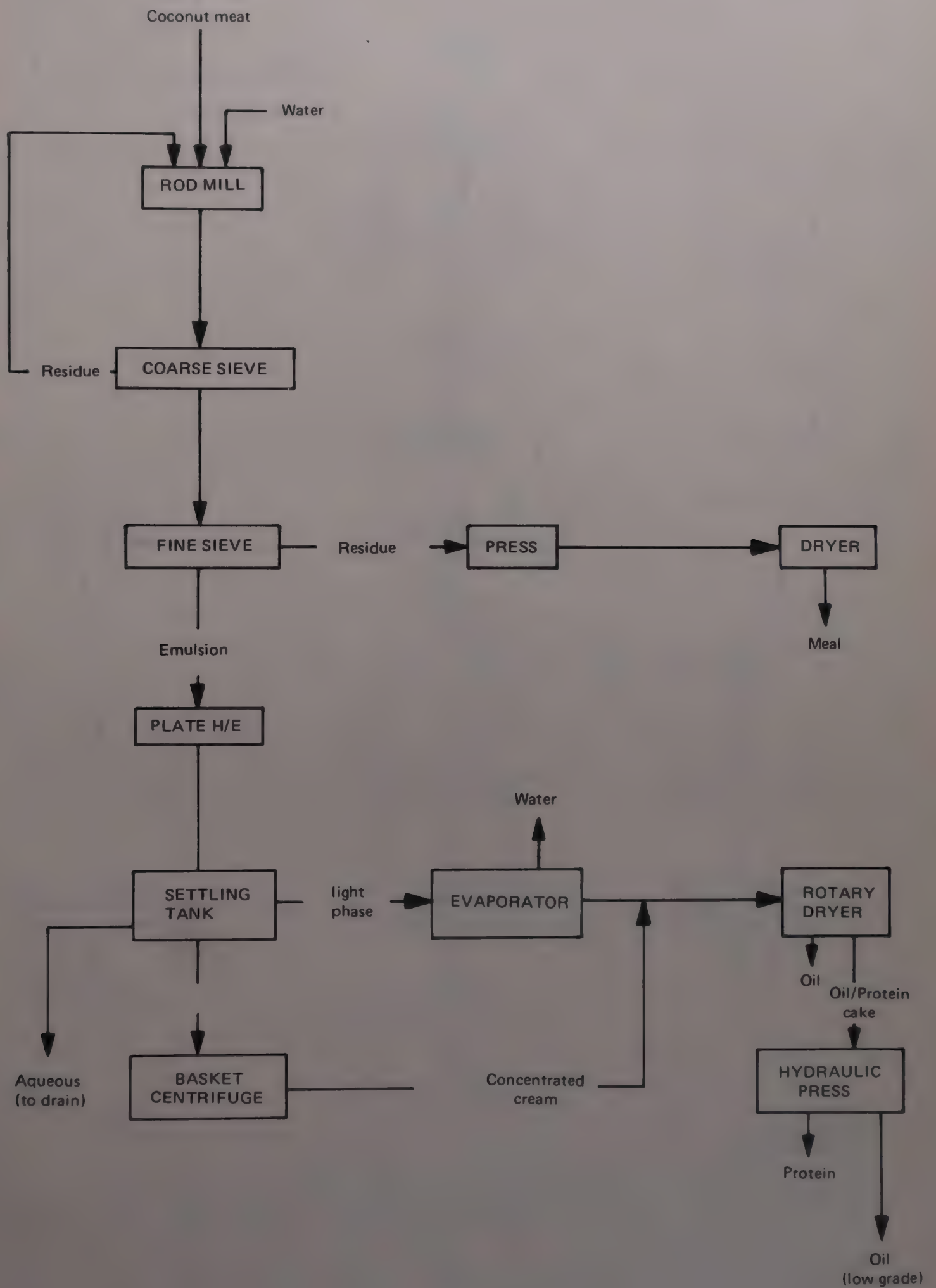
Source: Reference 99

Figure 2
Flow diagram: the Robledano-Luzuriage process



No data available on overall oil and protein yields.
Protein coagulate said to contain 60% protein.(20)

Figure 3
Flow diagram: the ICAITI process



No data available on product composition or protein yields.
Percentage oil recovery said to be between 75 – 80%. (45)

Figure 4
Flow diagram: the Krauss-Maffei process

Table 8
Percentage oil and protein yields

OIL	75 – 85%
PROTEIN	55 – 65%

Source: Reference 20

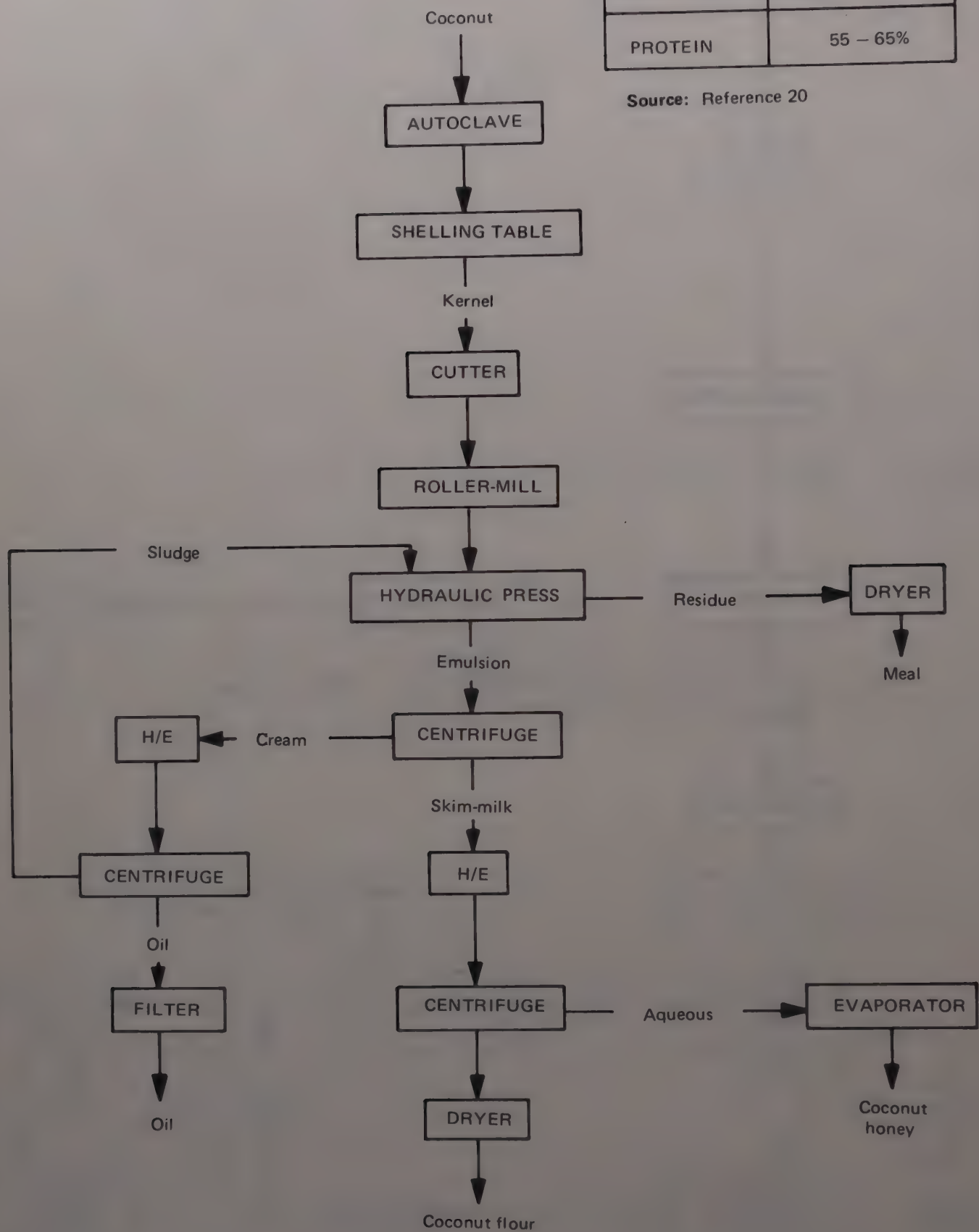


Table 9
Product composition

	% OIL	% PROTEIN	% MOISTURE	% CRUDE-FIBRE	% ASH
COCONUT FLOUR	3.4	51.7	8.4	0.5	8.2
MEAL	12.2	6.2	6.6	25.1	1.6

Source: Reference 20

Figure 5
Flow diagram: the Krauss-Maffei/CFTR1 process

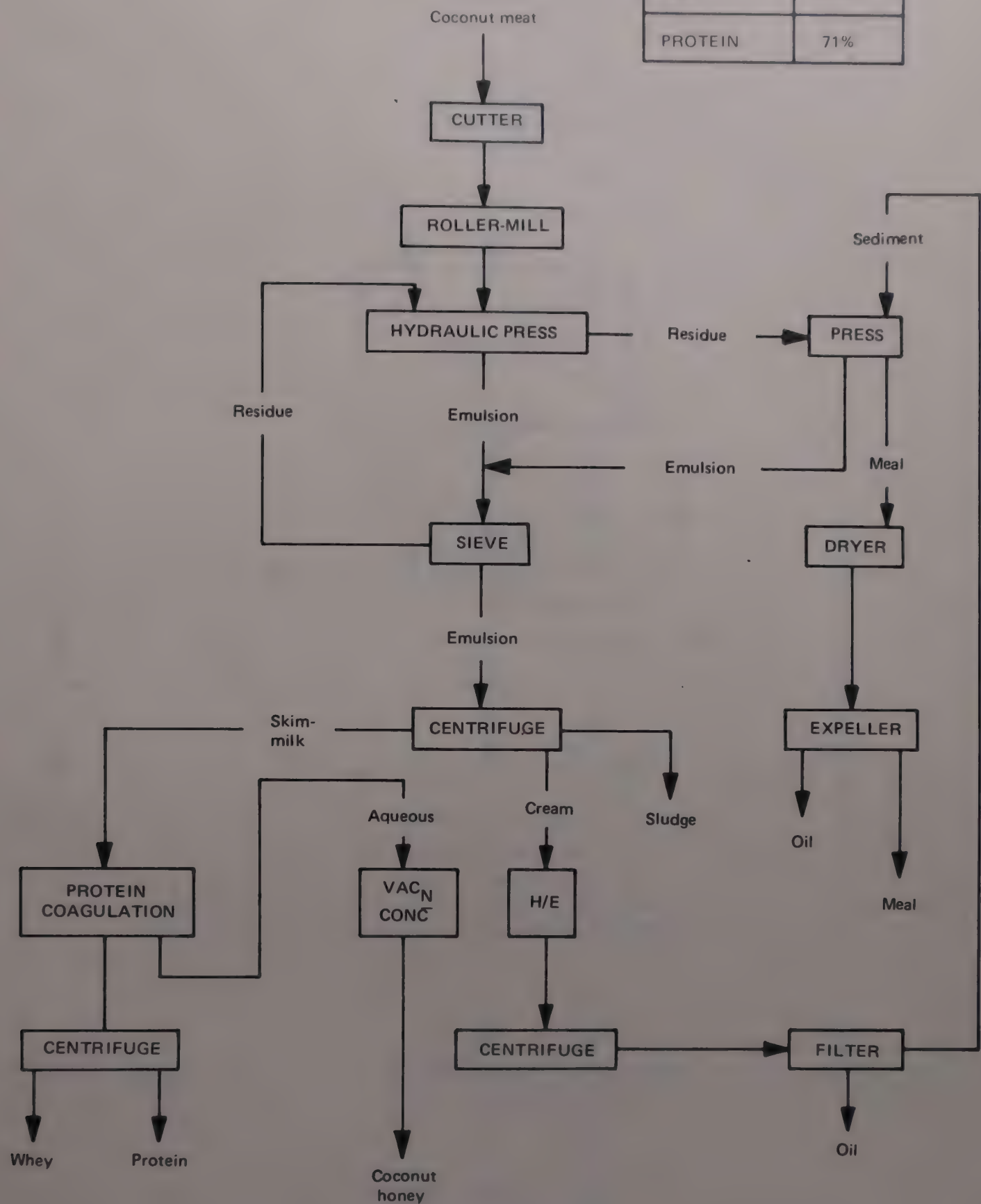


Table 10
Oil and protein yields

OIL	90%
PROTEIN	71%

Table 11
Product composition

	% OIL	% PROTEIN	% MOISTURE	% C-H	% ASH
PROTEIN	3.4	66.1	8.4	13.9	8.2
MEAL	25.0	6.0	6.0	57.0	6.0
HONEY	2.0	15.6	40.0	35.6	6.8

Source: Reference 20

Figure 6
Flow diagram: the Roxas process

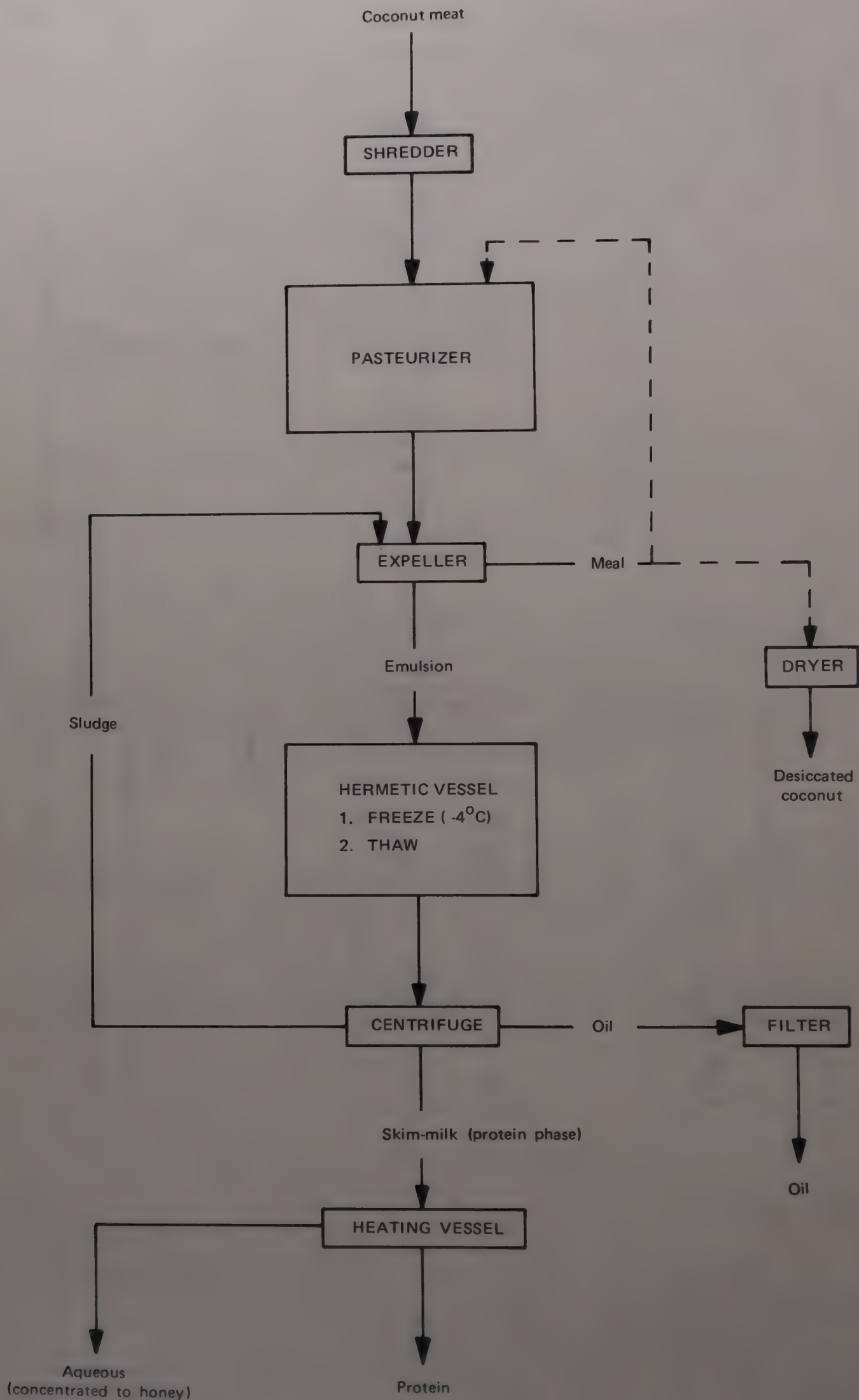
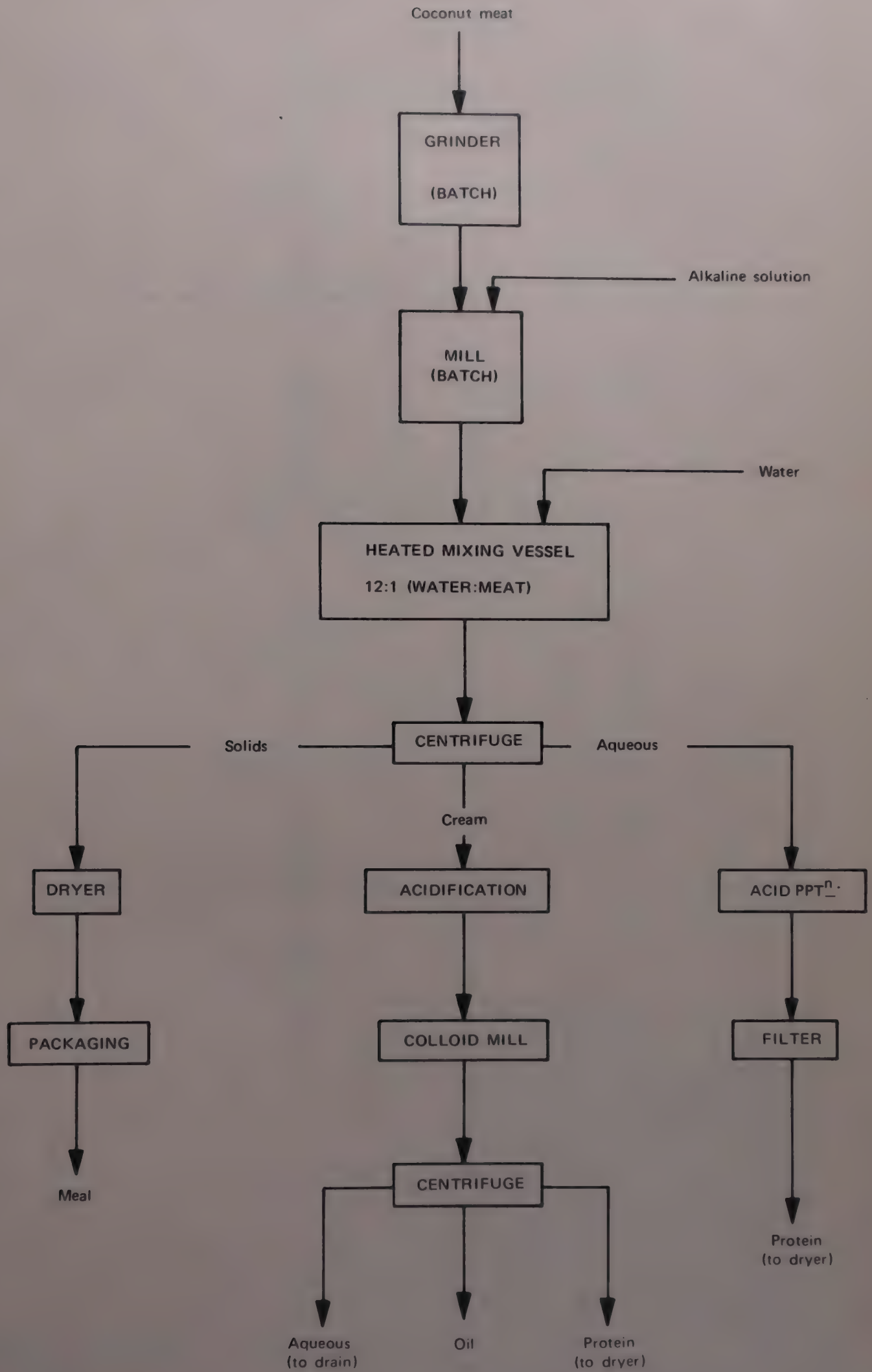


Figure 7
Flow diagram: the Sugarman process



No data available on oil and protein yields or product composition.

Figure 8
Flow diagram: the Hiller process

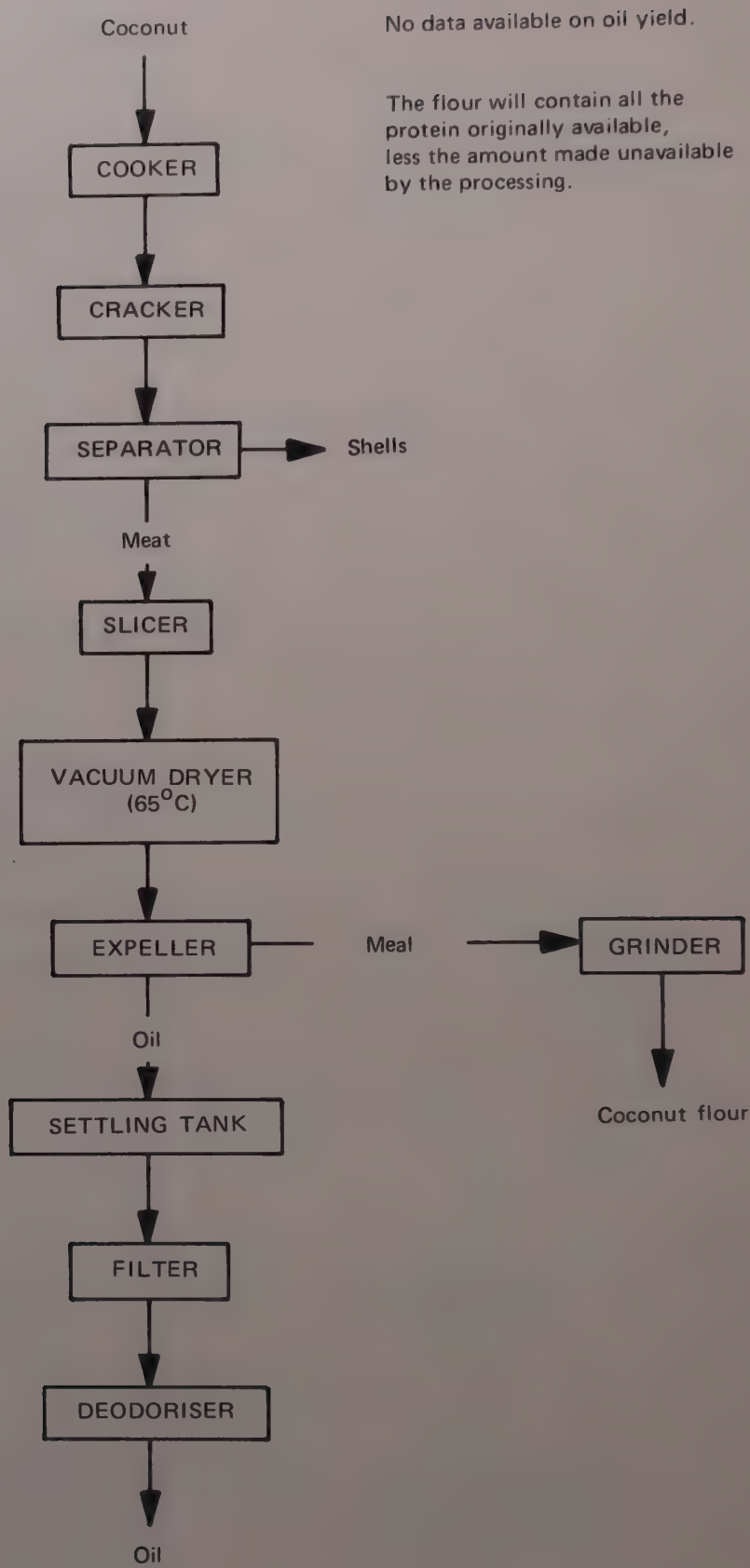
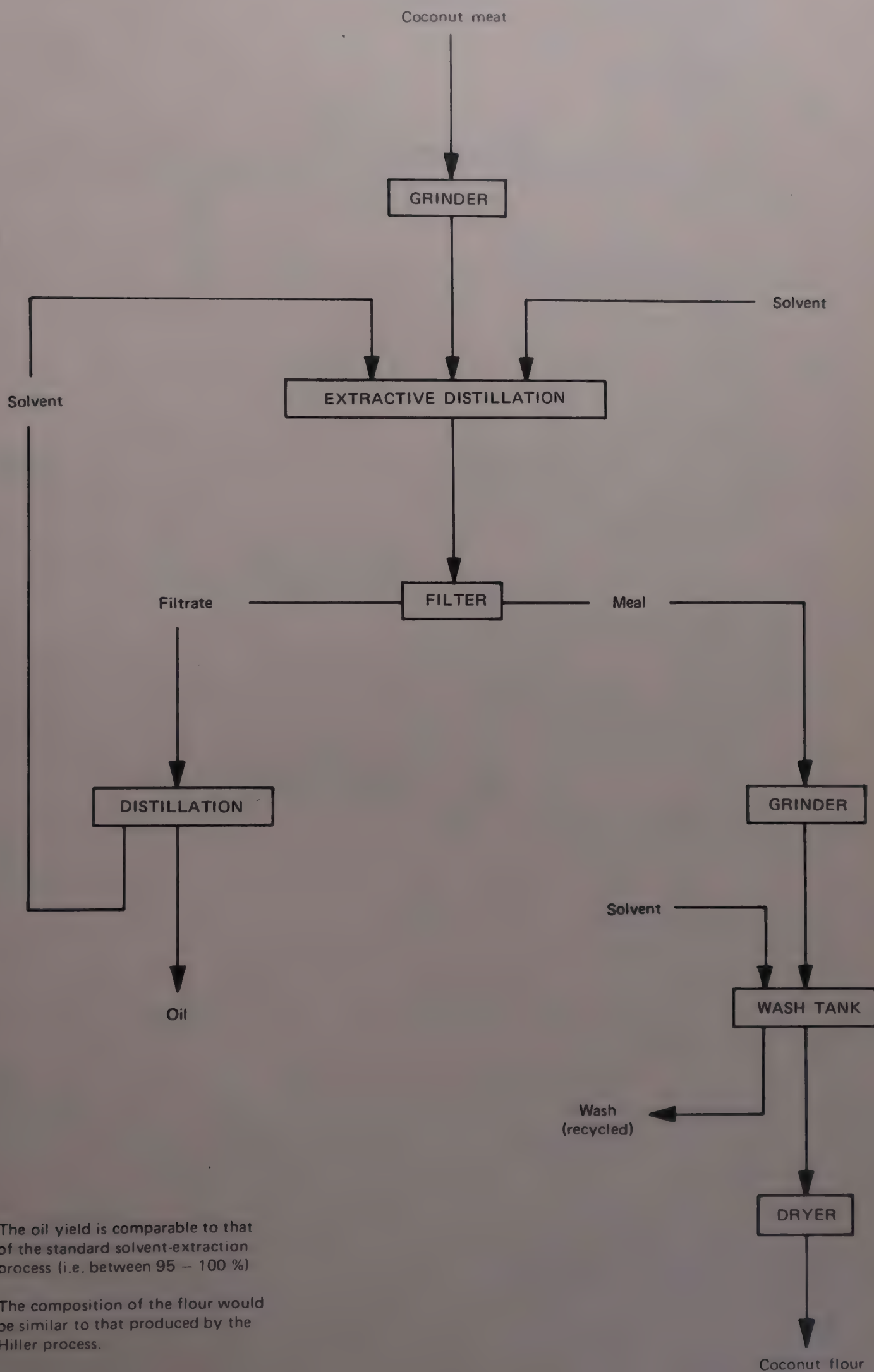


Table 12
Percentage composition of the coconut flour

Component	% wt.
OIL	12.2
PROTEIN	18.2
MOISTURE	6.2
CRUDE FIBRE	20.0
ASH	4.9
CARBOHYDRATES	20.4

Source: Reference 20

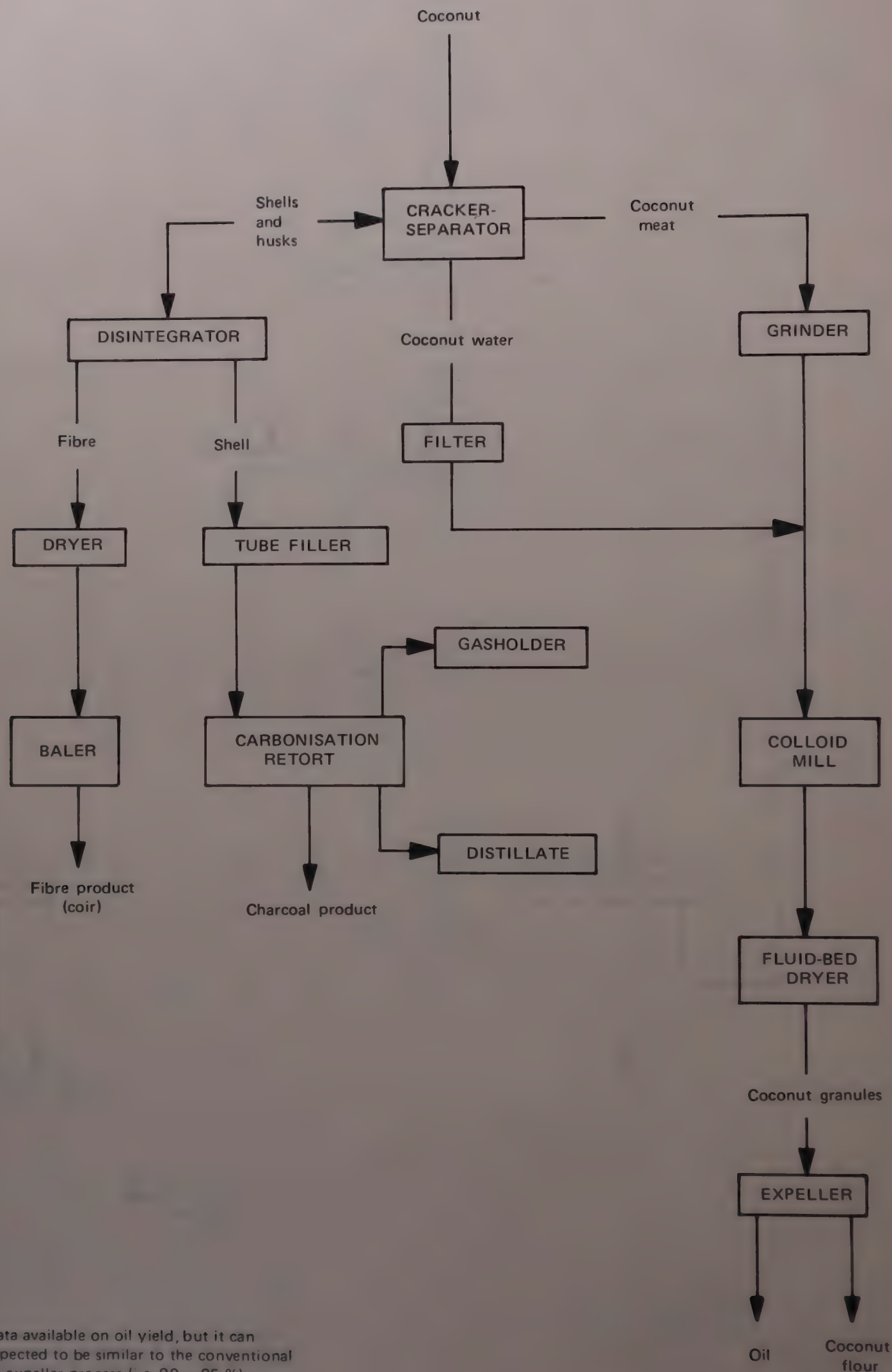
Figure 9
Flow diagram: the Azeotropic -- extraction process



The oil yield is comparable to that of the standard solvent-extraction process (i.e. between 95 – 100 %)

The composition of the flour would be similar to that produced by the Hiller process.

Figure 10
Flow diagram: the integrated coconut process



No data available on oil yield, but it can be expected to be similar to the conventional copra-expeller process (i.e. 90 – 95 %).

The Coconut Flour is said to have a minimum protein content of 20%, and a maximum fibre content of 8%. (33)

Figure 11
Flow diagram: the TPI process (102)

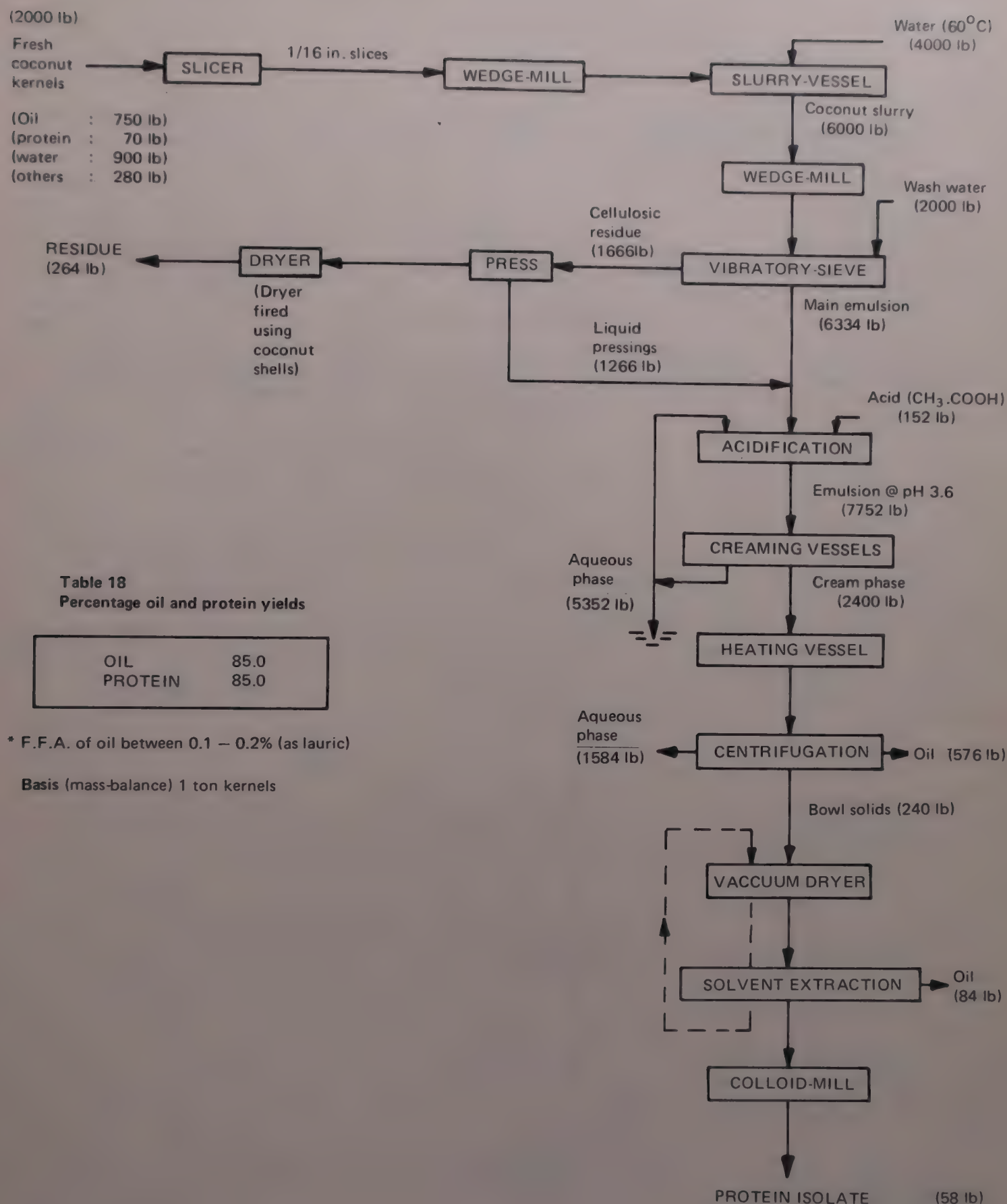


Table 19
Product composition

	% Oil (d.b.)	% Crude Protein (N ₂ x 6.25)	Moisture	% Crude Fibre	% Ash	% Carbohydrate (by difference)
PROTEIN ISOLATE	7.2	82.0	4.9	0.6	4.95	0.35
RESIDUE	36.4	4.8	5.0	43.6	0.4	9.8

Source: Reference 102

Figure 12
The TPI process (main stream) with possible alternative products

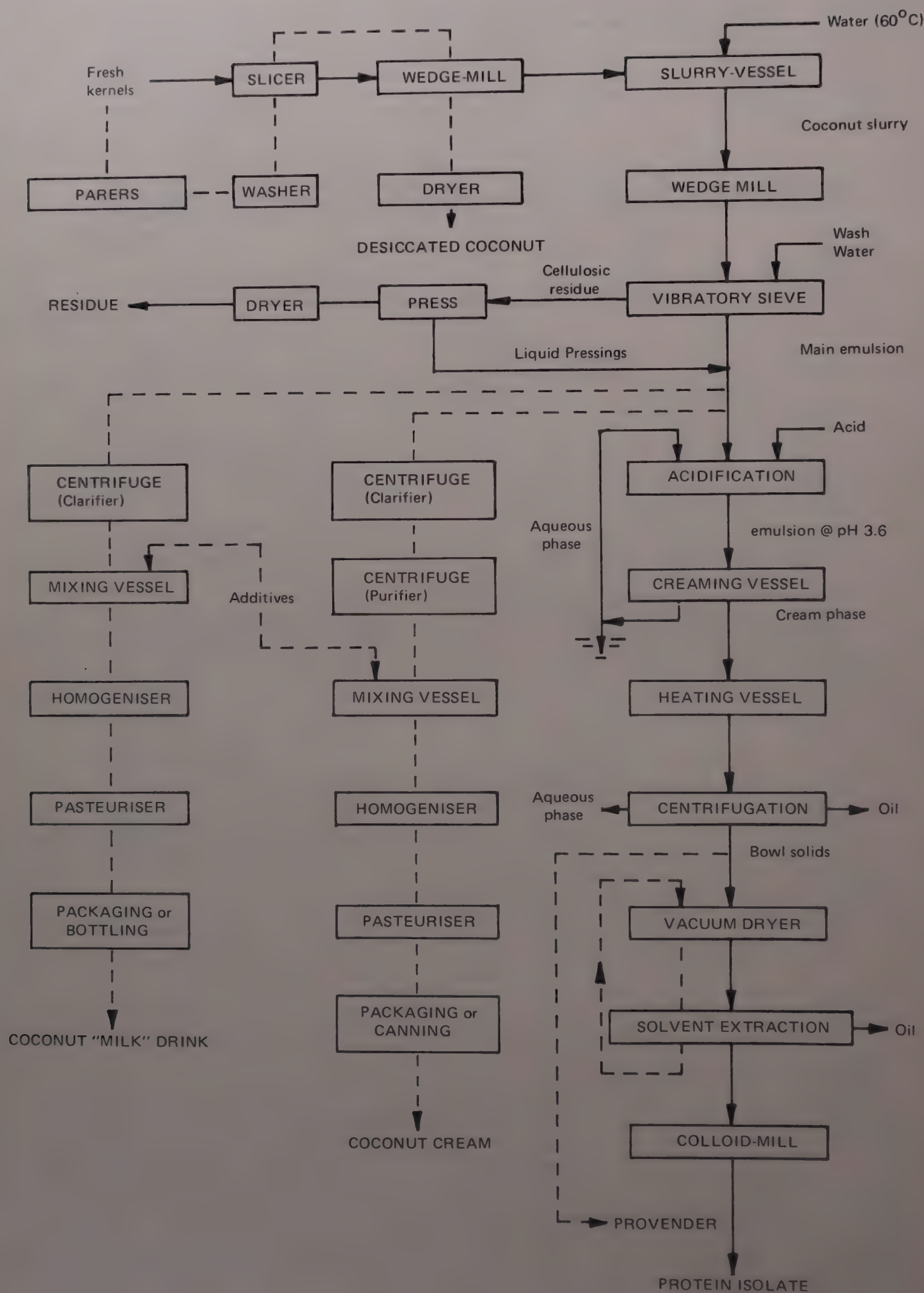
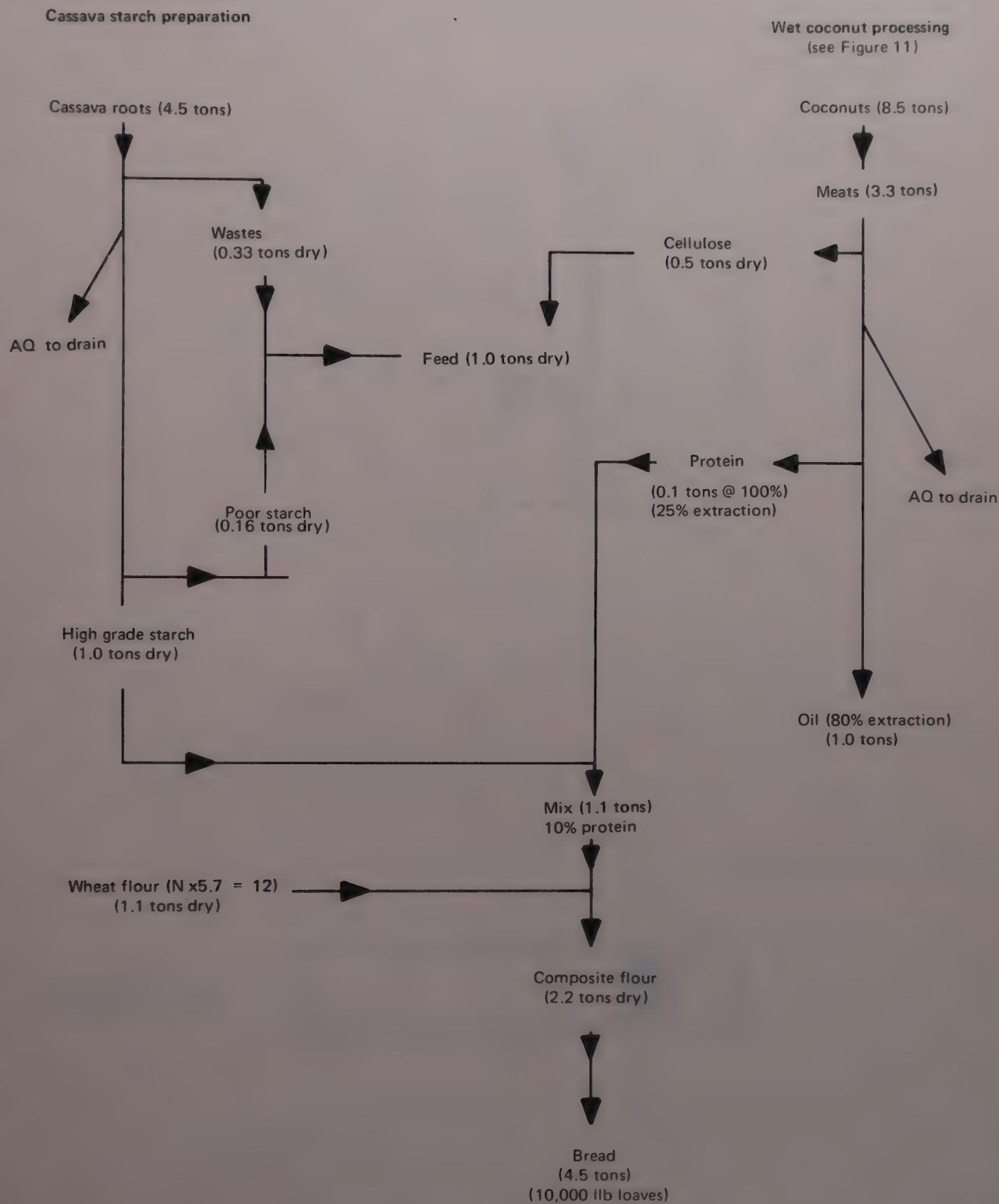


Figure 13
Putative integrated composite flour project



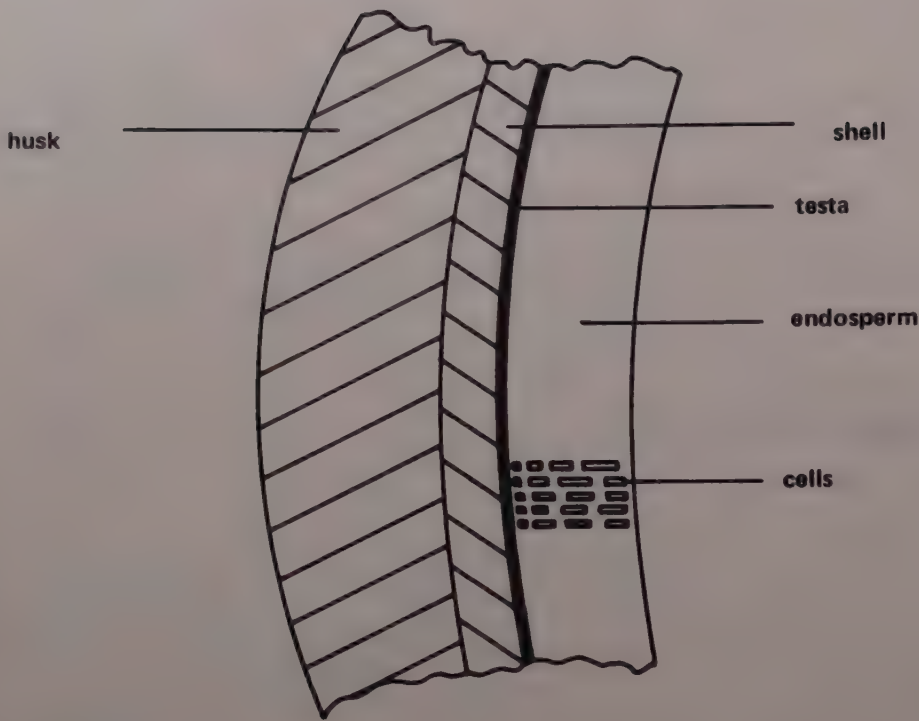
Approx. percentage composition of feed (dry wt)

Starch	16
Oil	20
Protein	3
Other (mainly cellulose)	61

Approx. percentage composition of composite flour

Protein	10.5
Total lysine in protein	3.0

Figure 14
(a) Cross-section through coconut



(b) Cross-section through endosperm cell

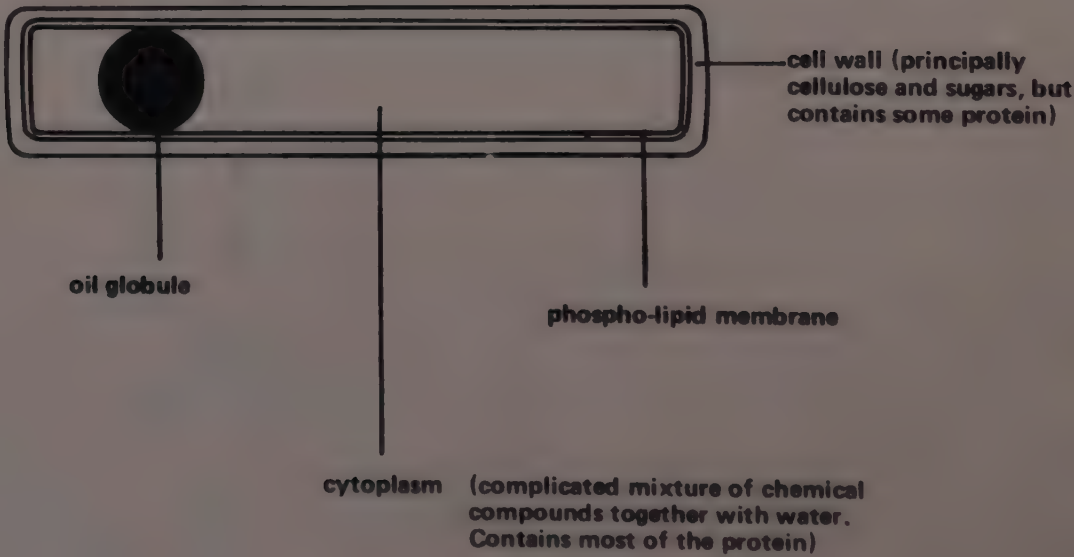


Figure 15
Drying curves for the cellulosic residue

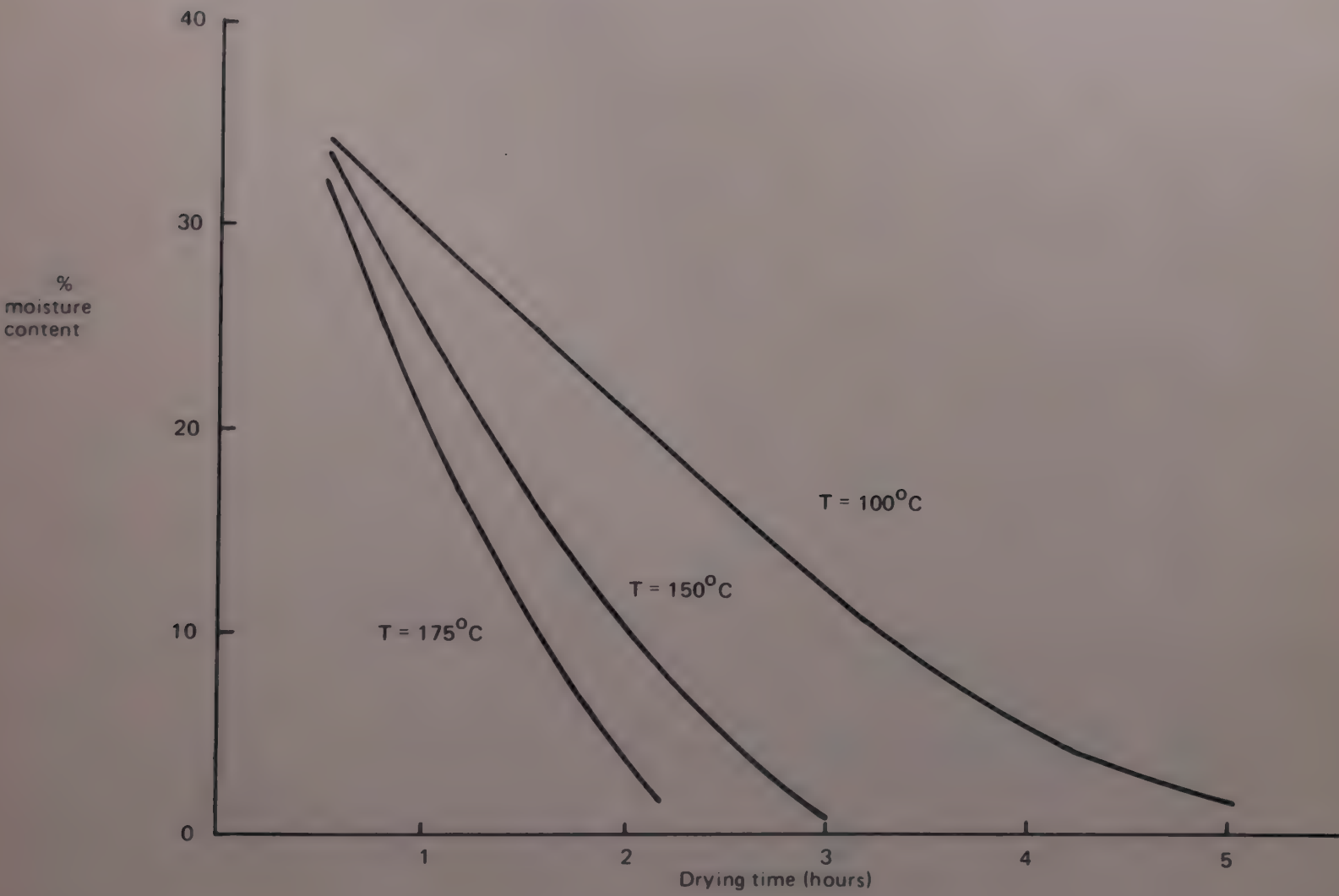


Figure 16
Residue size versus oil extraction

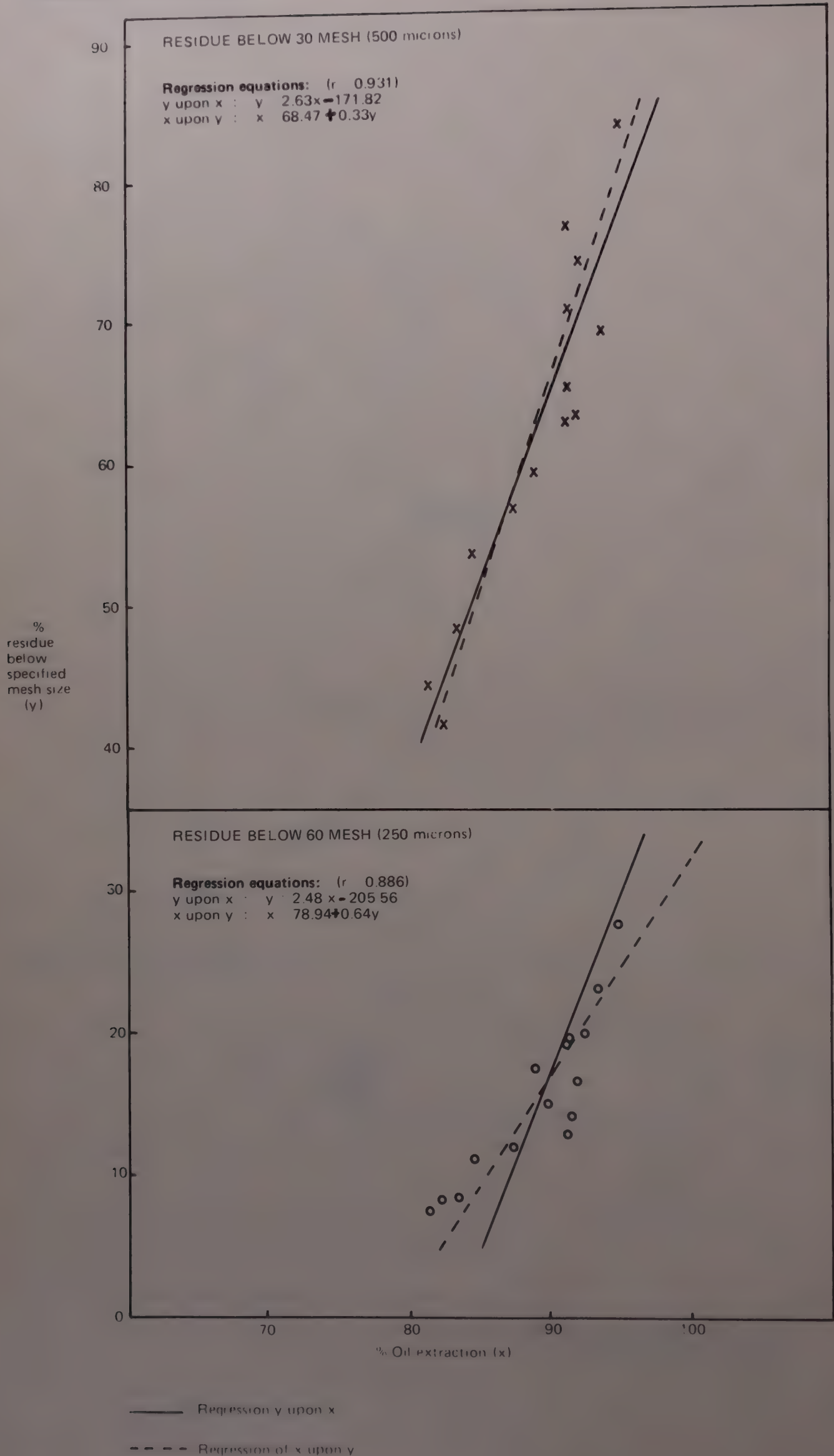
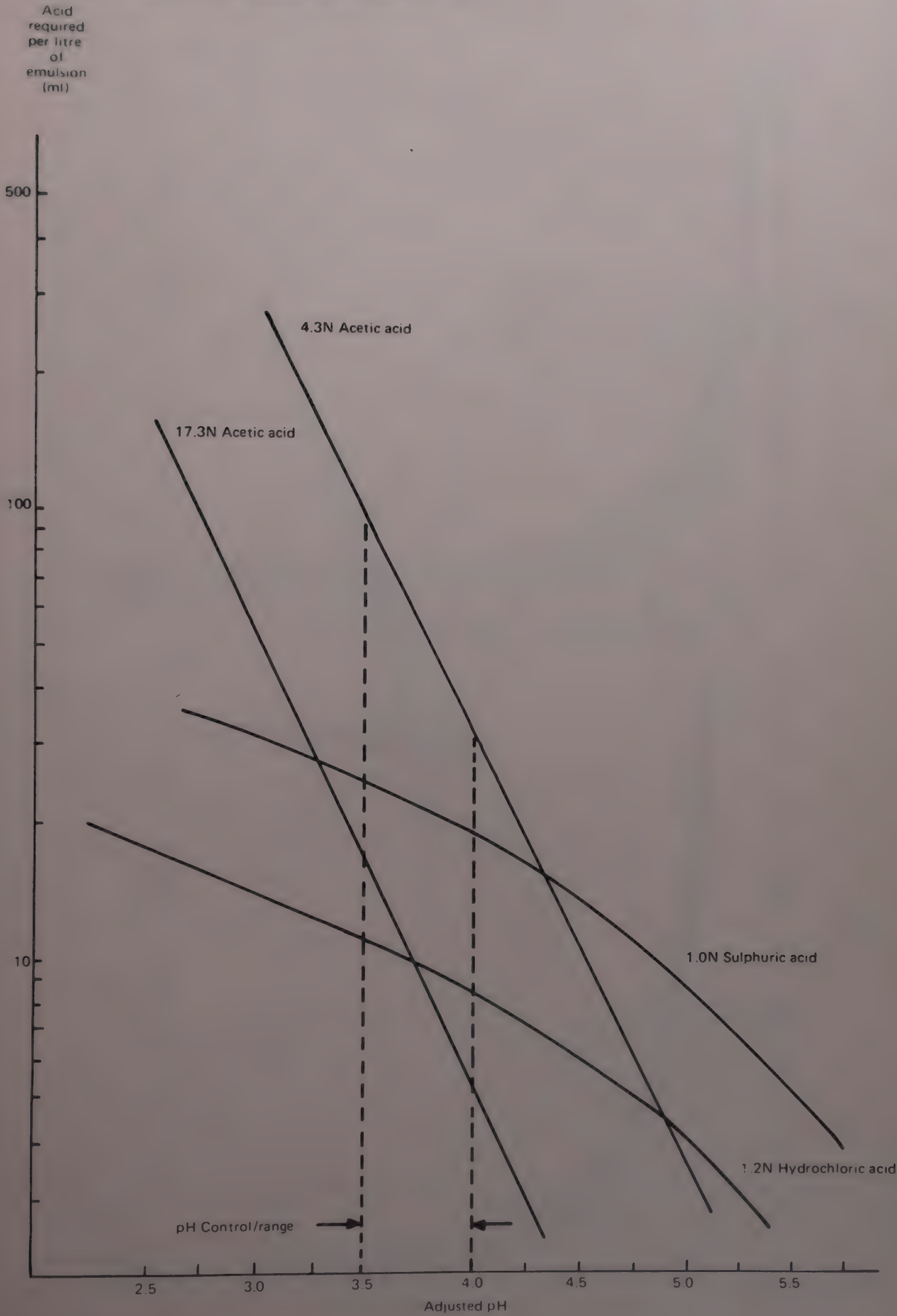


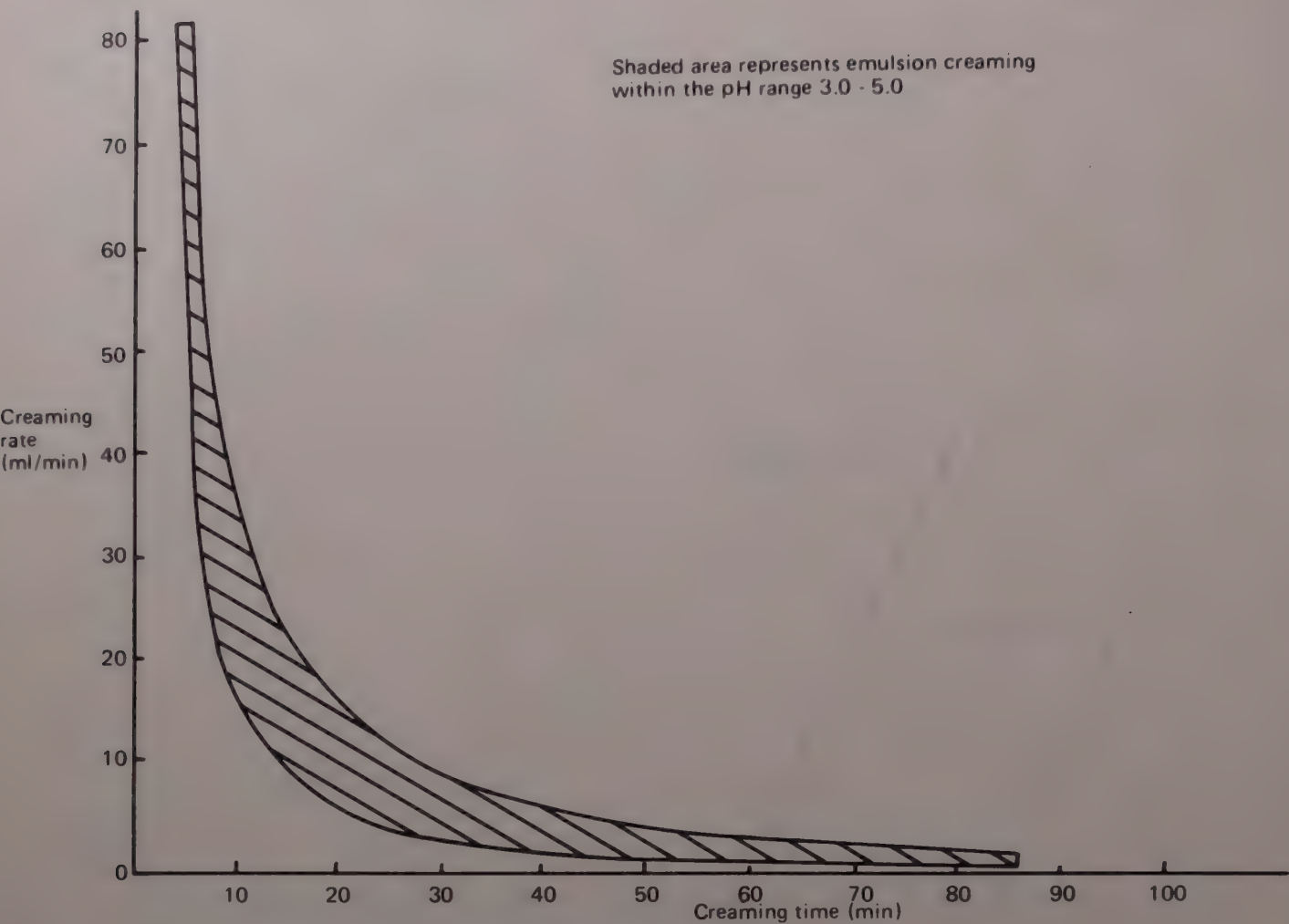
Figure 17
Acidification of the *emulsion using various acids



* Initial pH of the emulsion 6.8

Figure 18

(a) Creaming of the emulsion under acid conditions



(b) Creaming of the emulsion under alkaline conditions

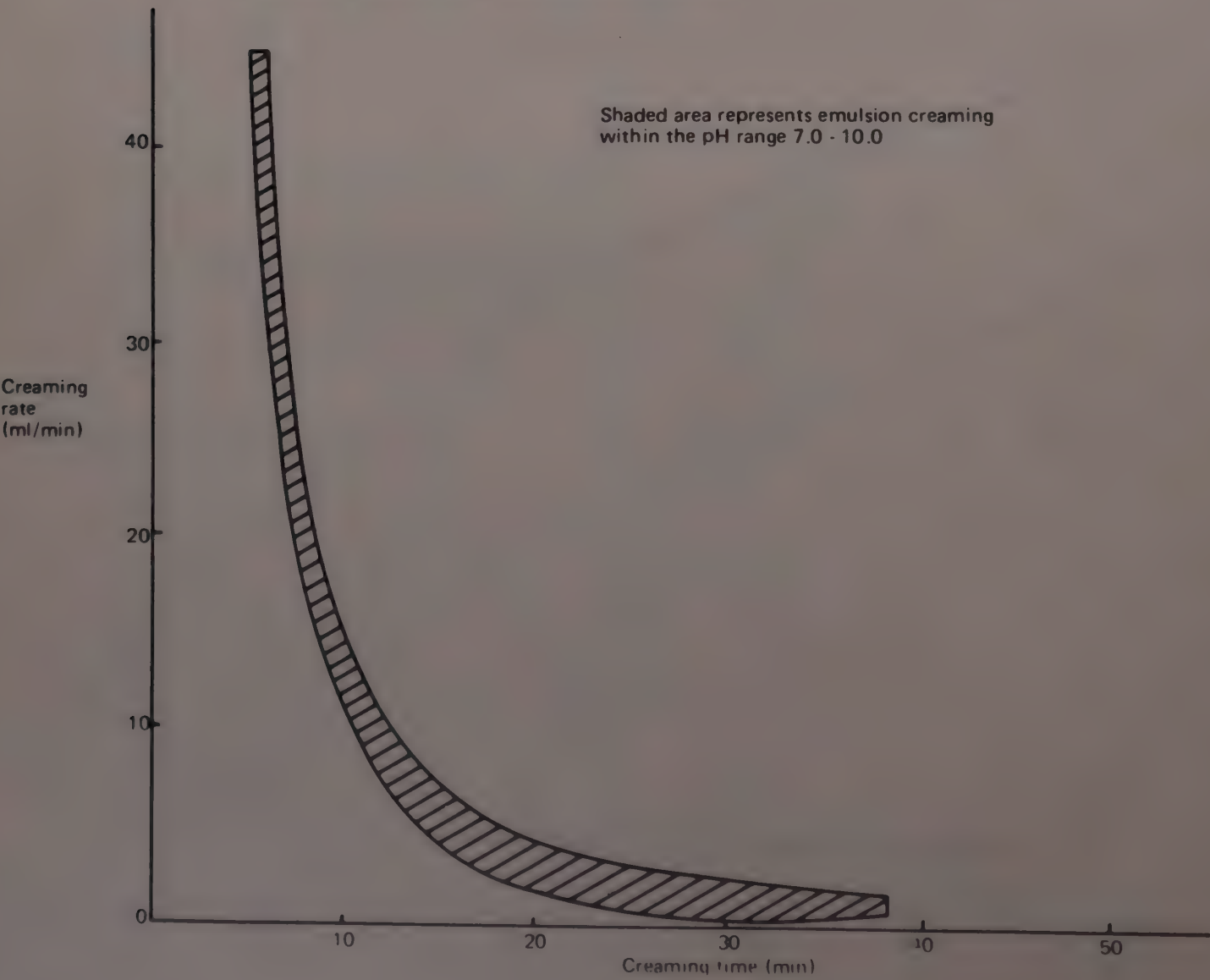


Figure 19
Acidification of the emulsion using acetic acid and recycled aqueous phase

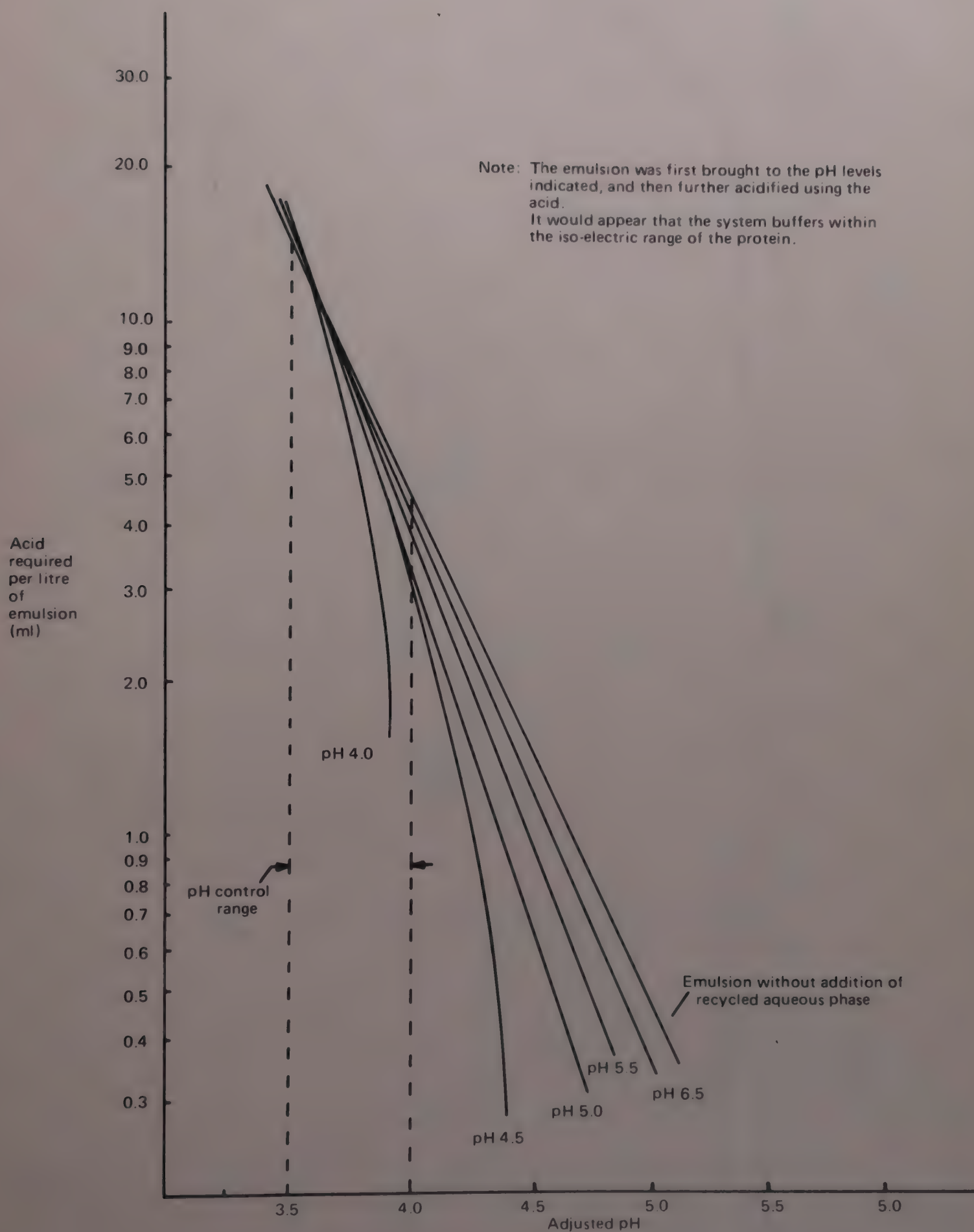


Figure 20
Oil globule size distribution within the emulsion

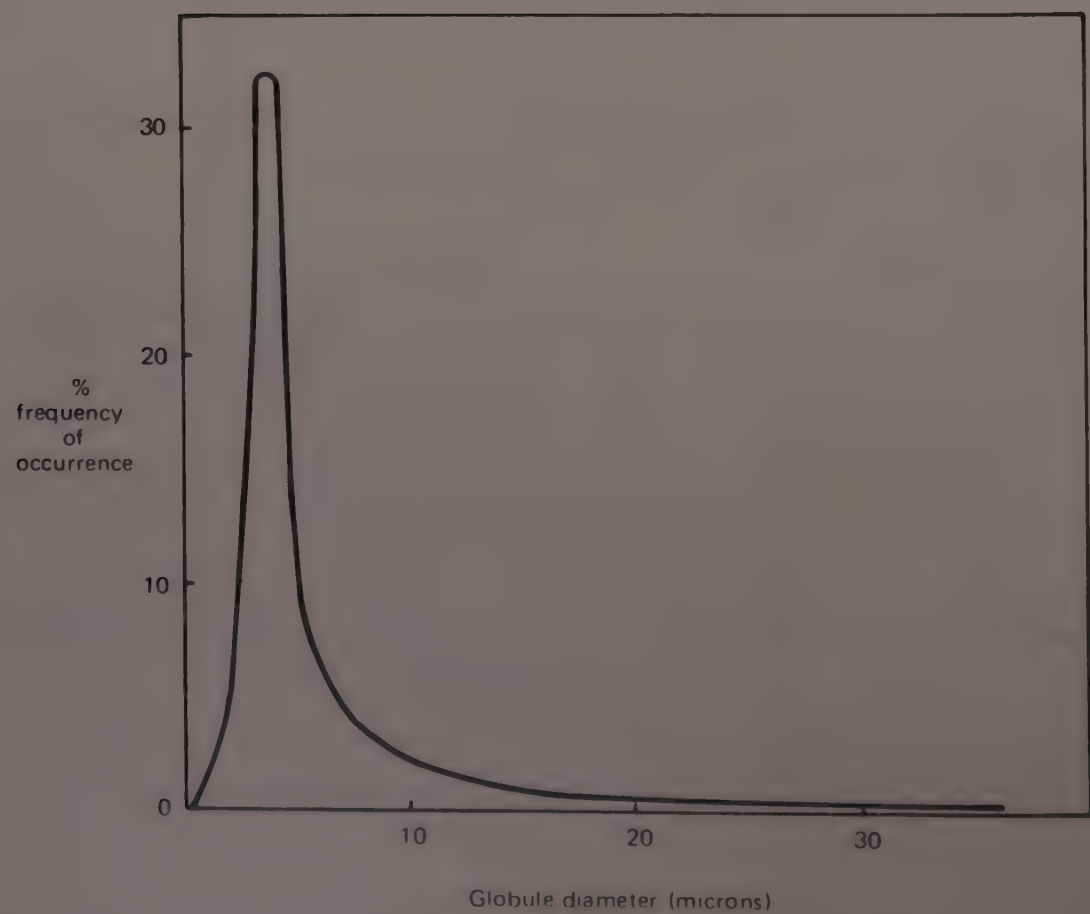
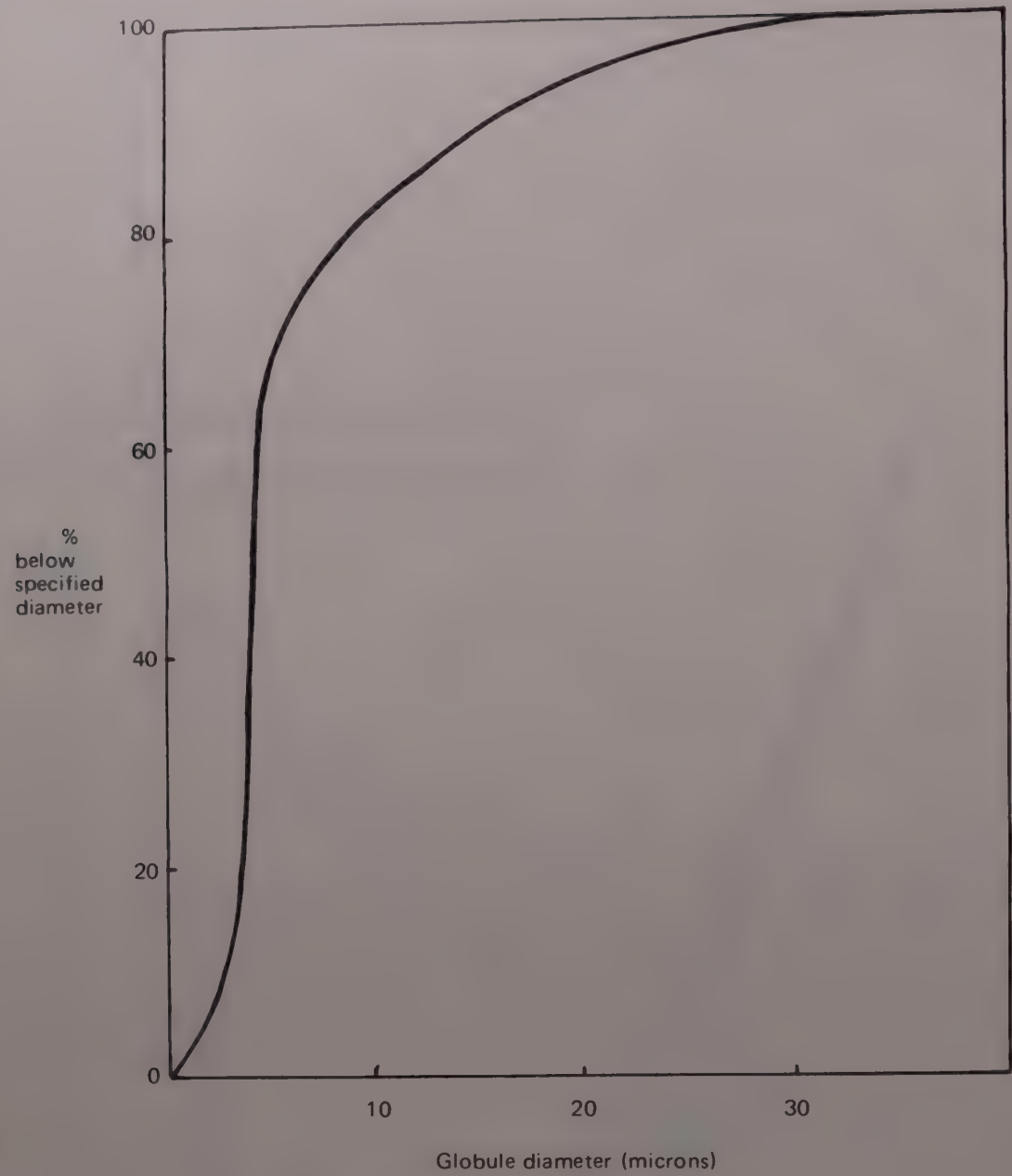


Figure 21
Centrifugal phase resolution of the emulsion

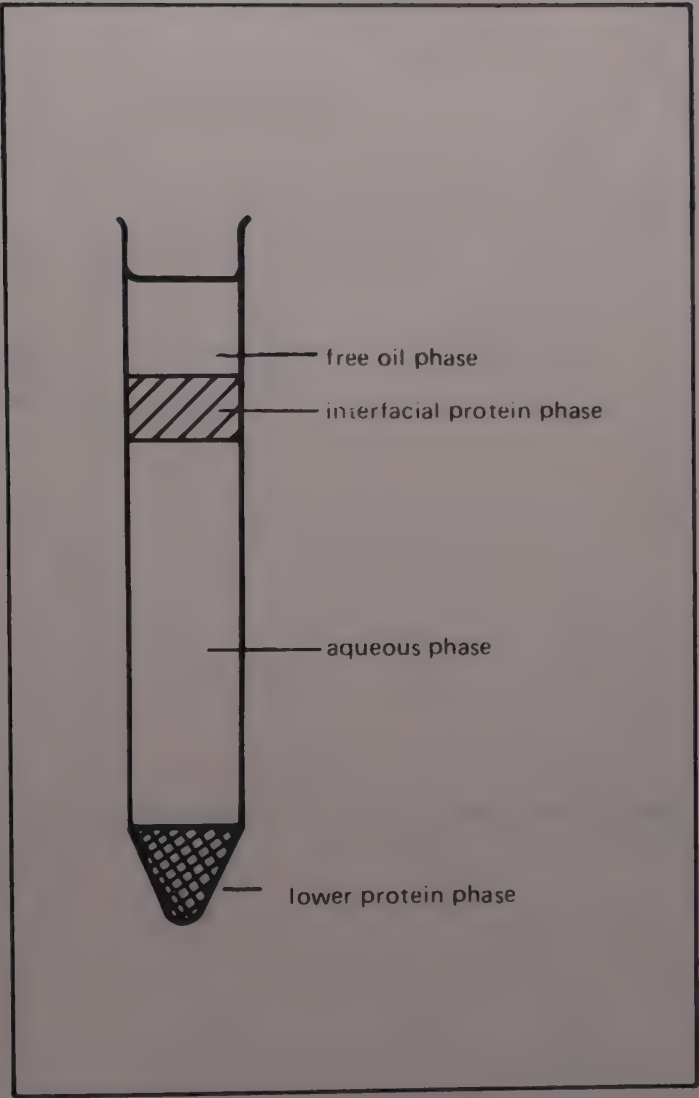


Figure 22
Effect of centrifugation period on the volumetric phase resolution of the emulsion

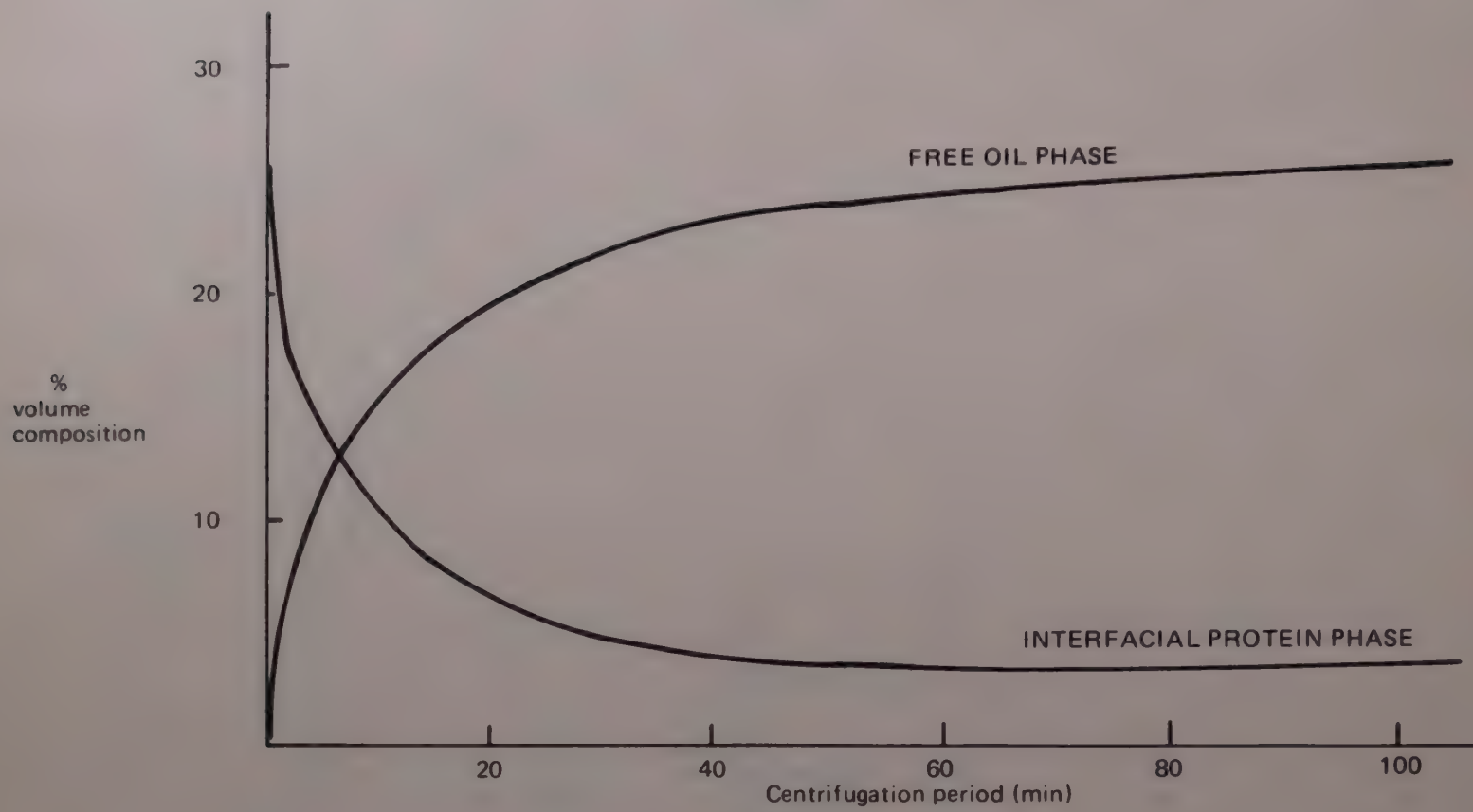


Figure 23
Effect of centrifugation period on the ratio between the interfacial protein phase and the lower protein phase

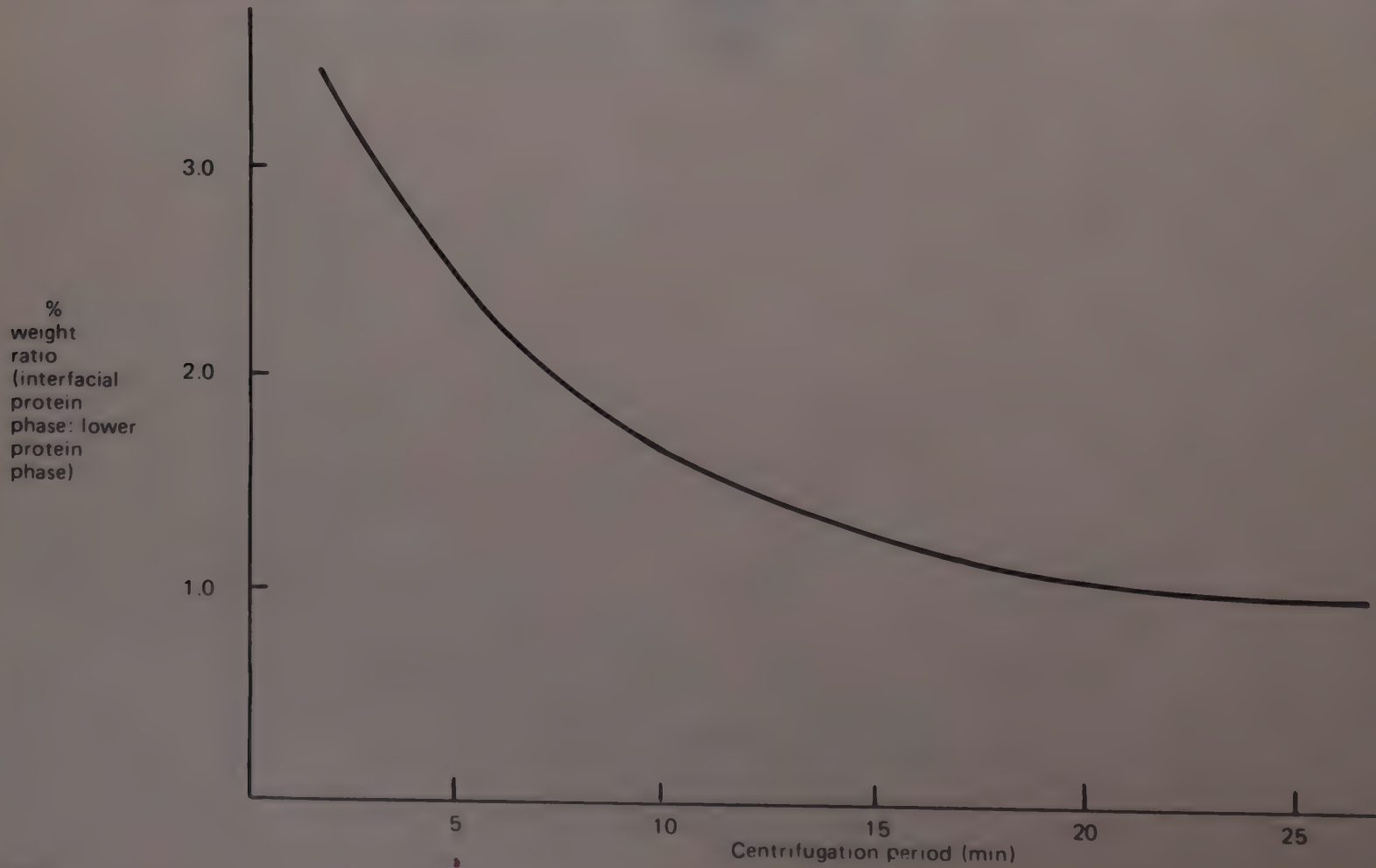
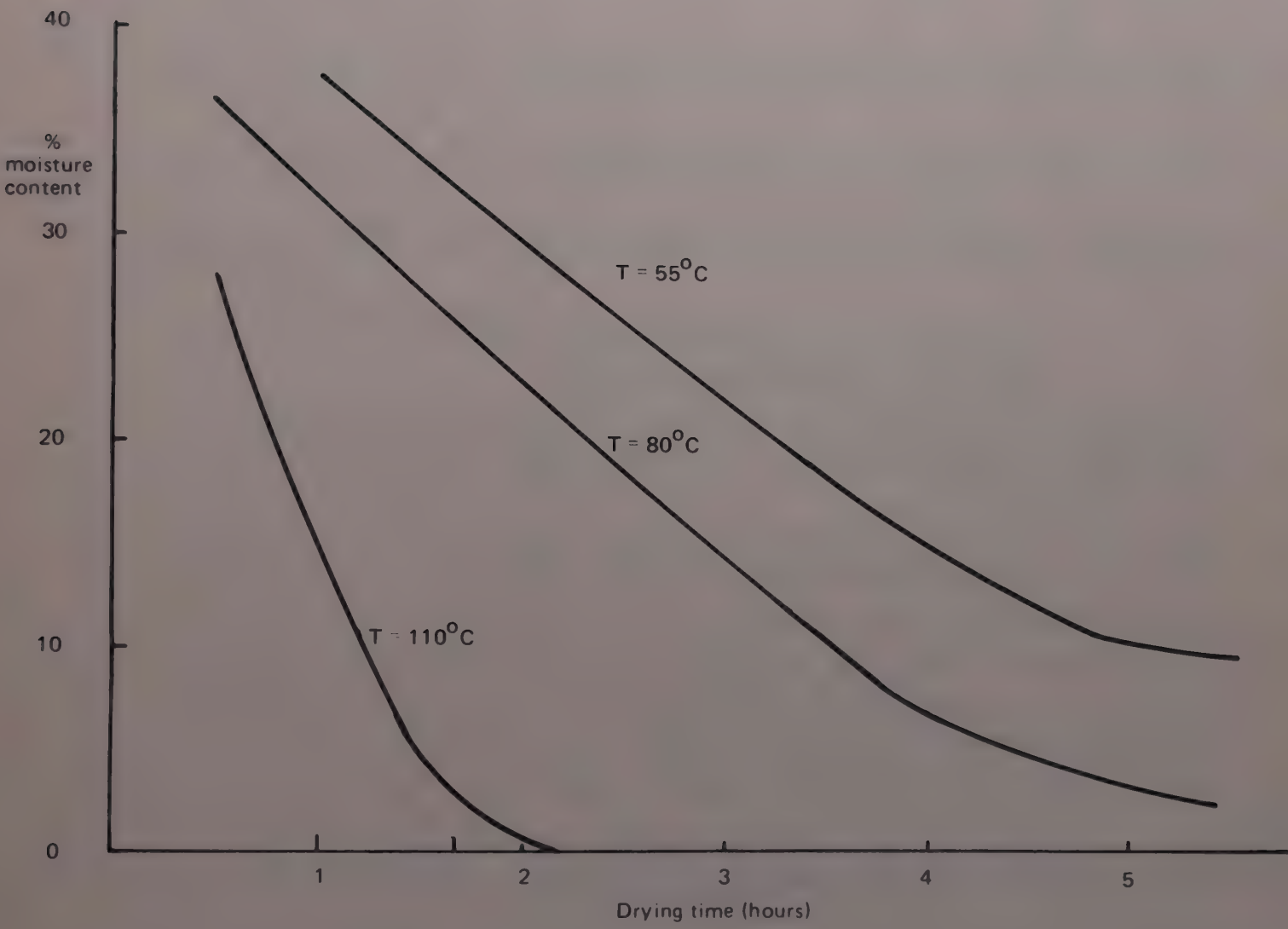


Figure 24
Drying curves for the centrifuge bowl solids (vacuum: 25 in. Hg)



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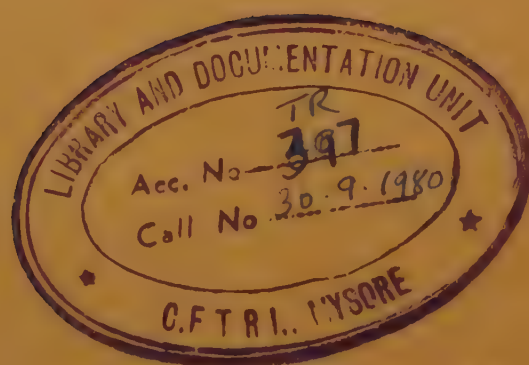
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An economic evaluation of the Wet Coconut Process developed at the Tropical Products Institute





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**An economic evaluation of
the Wet Coconut Process
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Tropical Products Institute**

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Tropical Products Institute 56/62 Gray's Inn Road London WC1X 8LU
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Summaries

SUMMARY

The Industrial Economics Section of TPI has carried out an appraisal of the economics of wet-processing coconut — with particular reference to the process developed at TPI. The method used was to construct model costings for enterprises based on the copra drying/expeller process and on the wet coconut process, and to compare the relative costs and benefits of each. Malaysia costs were used in the greater part of the appraisal, principally because a great deal more information was available for that country's coconut industry than for others, but subsidiary costing exercises were made for Jamaica and Ceylon, to look specifically at the effect of very high and low wages respectively. Costs were first assessed on a commercial or existing market price basis, and were then adjusted by the use of social cost/benefit analysis techniques to 'shadow' on real scarcity costs in order to gauge the benefit to the whole economy in question, rather than to the processing enterprise.

The most important component of costs of either process was that of the raw materials, mainly the coconuts themselves, which was the same in either case, since both processes start with the same material. The labour cost of processing the wet coconuts on the one hand, and of expelling the dried copra on the other, into oil was an important component, and here it was found that the costs of the wet coconut process were 3 to 4 times greater than those of the expeller process. Other operating costs were virtually identical. The remaining difference between the two processes, that of drying the copra, was found to be of crucial importance. In cases where a high cost of copra drying was postulated, for example where it is done inefficiently with high losses through spoilage, or in small amounts by scattered small-holders, then the wet-coconut process was found to be more advantageous. However, in cases where copra drying is carried out efficiently by approved methods, and where the industry is properly co-ordinated, it was found that this was undoubtedly the most beneficial means of processing. In many cases, moreover, there is likely to be a cost differential between the process resulting from the fact that it would be necessary to transport bulky whole coconuts rather than compact copra in the wet coconut process. A further advantage of the expeller process is the lower capital cost involved.

It appeared, then, that the wet coconut process would be of advantage in cases where an inefficient oil-expelling industry existed. On closer inspection this argument appears to be false. The advantages claimed for the wet coconut process were that it would reduce waste from spoilage etc. common to the expeller process, that a higher quality oil which would command a premium price would be forthcoming, and that the protein by-product from the process would make a valuable addition to revenue as well as providing a needed addition to the food-producing capacity of coconut-producing countries. In practice spoilage etc can be equally well reduced by improving the efficiency and operating practices of copra drying/expelling industries, an equally high quality oil can be produced, moreover with higher yields, in terms of revenue, the sales of copra cake are likely to be more valuable than sale of protein, and in any case the yield of protein is low and may not command a ready market

La section d'économie industrielle de TPI a effectué une évaluation de l'économie du traitement des noix de coco par voie humide, en se référant en particulier au procédé développé à TPI. La méthode utilisée consista à établir pour des entreprises, des modèles des prix de revient basés sur le procédé de séchage/tourteau de copra et sur le procédé de traitement des noix de coco par voie humide, puis à comparer les prix et avantages relatifs de chacun. Dans la majeure partie de l'évaluation, on se servit des prix applicables en Malaisie, principalement parce que le volume des données pour son industrie des noix de coco était plus important que celui des autres pays, mais on entreprit des calculs subsidiaires des prix de revient pour la Jamaïque et Ceylan, afin d'étudier spécifiquement l'effet de salaires respectivement très élevés et très bas. L'évaluation fut d'abord basée sur les tarifs commerciaux et sur le cours du marché actuel, puis ajustée à l'aide de techniques d'analyse des coûts/indemnités sociales afin de tenir compte du manque réel d'abondance dans les prix, et de façon à évaluer les avantages pour toute l'économie en question, plutôt que pour l'entreprise de traitement.

La partie la plus importante du coût du procédé, la même dans chaque cas, étant donné qu'ils partent tous deux du même matériau, était le prix des matières premières, principalement les noix de coco. Le coût de la main d'oeuvre pour l'extraction de l'huile soit des noix de coco par voie humide, soit des tourteaux de copra, était important, et on trouva que les frais de traitement des noix de coco par voie humide étaient de 3 à 4 fois plus élevés que ceux du traitement des tourteaux. Les autres frais de l'opération étaient à peu près identiques. La seule différence entre les deux procédés, le séchage du copra, était d'importance décisive. Dans les cas où le séchage du copra exigeait des prix élevés par exemple où celui-ci était effectué de façon inefficace avec des pertes importantes dûes à la détérioration, ou en faibles quantités par de petits cultivateurs dispersés, on trouva alors le procédé de traitement des noix de coco par voie humide plus avantageux. Cependant, dans les cas où le séchage du copra est entrepris efficacement par des méthodes classiques, et où l'industrie est bien coordonnée, on trouva que celui-ci est absolument le moyen de traitement le plus avantageux. De plus, il est souvent possible qu'il existe une différence de prix entre les deux procédés découlant du fait que pour le procédé par voie humide, il est nécessaire de transporter les noix de coco entières et encombrantes plutôt que le copra moins volumineux. La nécessité de capitaux moins élevés est un autre avantage du procédé de tourteaux.

Il sembla alors que le procédé de traitement des noix de coco par voie humide serait avantageux dans les cas où l'industrie des tourteaux oléagineux est peu efficace. Ce raisonnement s'avère faux lorsqu'on l'étudie plus profondément. Les avantages attribués au procédé par voie humide sont: qu'il réduirait le gaspillage causé par la détérioration, courant dans le procédé des tourteaux, qu'il en découlerait une huile de meilleure qualité pouvant se vendre à bon prix et que les protéines, sous-produits de ce procédé, viendraient s'ajouter avantageusement au revenu, tout en suppléant la production alimentaire des pays producteurs de noix de coco. En pratique, le gaspillage peut aussi très bien être réduit par l'amélioration de l'efficacité et des modes opératoires des industries de séchage/tourteaux de copra, une huile d'aussi bonne qualité peut être produite avec en plus des rendements meilleurs; en ce qui concerne les revenus, la vente des gâteaux de copra sera probablement plus profitable que la vente des protéines, et de toute façon le rendement en protéines est faible et n'aura peut-être pas à sa disposition la maîtrise d'un marché.

La Sección de Economía Industrial de TPI ha realizado una valoración de los aspectos económicos del proceso húmedo de la nuez de coco, con referencia especial al proceso desarrollado por TPI. El método empleado fue la elaboración de modelos de estimación del coste para empresas basadas en el proceso de secado/extracción de aceite de la copra y en el proceso húmedo de la nuez de coco, y la comparación de los costos y la rentabilidad de cada uno de estos procesos respectivamente. En la mayor parte de esta valoración se emplearon los costos en Malasia, principalmente debido a que se disponía de mucha más información sobre la industria de la nuez de coco de este país que de ningún otro, aunque se llevaron a cabo ejercicios de estimación de costos subsidiarios en Jamaica y en Ceilán, con objeto de estudiar específicamente los efectos de los salarios muy altos y muy bajos respectivamente. Los costos se determinaron en primer lugar sobre bases comerciales o precios actuales del mercado, y se ajustaron a continuación mediante el empleo de técnicas de análisis de costos/beneficios sociales para arreglar a los costos reales de escasez, con objeto de estimar los beneficios aportados a la economía total en cuestión, en vez de los beneficios de la empresa elaboradora.

El elemento más importante de los costos de ambos procesos era las materias primas, es decir, los cocos mismos, que resultaba ser el mismo en ambos casos, puesto que los dos procesos comienzan con el mismo material. Los costos de mano de obra del proceso húmedo, por una parte, y de la extracción del aceite de la copra seca, de la otra parte, representaban un elemento importante, y se halló que los costos del proceso húmedo de la nuez de coco eran de 3 a 4 veces más elevados que los del proceso de extracción. Los otros costos de explotación son prácticamente idénticos. La única otra diferencia entre los dos procesos, es decir, el secado de la copra, resultó ser de importancia decisiva. En los casos en que se estableció un coste elevado del secado de la copra, por ejemplo cuando se hace ineficientemente con grandes pérdidas debidas a desperdicios o cuando la realizan en pequeña escala los pequeños propietarios diseminados por el país, se halló que el proceso húmedo de la nuez de coco era más ventajoso. No obstante, en los casos en que el secado de la copra se realiza eficientemente mediante métodos aprobados, y cuando la industria está bien coordinada, se halló que éste era indudablemente el método más beneficioso de realizar el proceso. En muchos casos, sin embargo, es probable que exista una diferencia de costos entre estos procesos resultante de la necesidad de transportar cocos enteros voluminosos en vez de la copra compacta en el proceso húmedo. Una ventaja más del proceso de extracción es que se necesita menor inversión de capital.

Parecía, por lo tanto, que el proceso húmedo de la nuez de coco sería ventajoso en los casos en que existiera una industria de extracción de aceite ineficiente. Este argumento parece ser falso cuando se analiza más detenidamente. Las ventajas alegadas en favor del proceso húmedo eran que reduciría las pérdidas por desperdicio, etc. comunes al proceso de extracción, que se obtendría aceite de mejor calidad del que se conseguiría mayor precio y que la proteína obtenida como subproducto del proceso no solamente aumentaría los ingresos sino que además proporcionaría un aumento necesario de la capacidad de producción de alimentos de los países productores de cocos. En la práctica los desperdicios, etc. se pueden reducir igualmente mejorando la eficiencia y las prácticas de manejo de las industrias de secado/extracción de aceite de la copra, y se puede obtener aceite de la misma alta calidad, además, con mayor rendimiento, en términos de ingresos, las ventas de torta de copra son probablemente más valiosas que la venta de proteína, y en todo caso el rendimiento de proteína es bajo y puede no encontrarse mercados donde venderla.

An economic evaluation of the Wet Coconut Process developed at the Tropical Products Institute

THE PROBLEM

This report sets out to compare the costs and benefits of using coconuts to produce oil and copra cake by means of the conventional copra drier expeller process with those of a process developed at TPI for producing oil and a pure protein extract directly from fresh coconuts. The two processes in question are described briefly in the following note: ⁽¹⁾

'The coconut would be a valuable source of high grade protein if a suitable method of extraction could be devised. The traditional method of oil extraction is to dry the flesh of the coconut to give copra, which is pressed at a high temperature to extract the oil. The residues containing the protein are fit only for animal feed and the oil is of poor quality. It should be possible to extract oil and protein from fresh coconuts without the use of long periods of drying or high temperature.

'Intensive study of possible extraction systems has led to the development of an outline process, which yields a very high quality oil and a protein concentrate which could be used to supplement bread and other foods without adverse effects on flavour or texture. In the outline process, diced or coarsely minced coconut flesh is milled in the presence of water to a fine suspension using a wedge/dieplate machine. The solids, mainly cellulose, are separated by sieving and pressing, the emulsion obtained being creamed by acidification and the cream then being centrifuged to yield clear oil, water and protein.'

It was anticipated that the process should be explored and defined fully in the course of pilot scale trials to be carried out in a coconut producing country. Before a pilot project can be set up, there were certain tasks to be performed by economists. These were:

1. To assess the general viability and applicability of the new process.
2. If the outcome of the first stage were auspicious and the conditions for viability of the new process are defined, it would then be necessary to identify a suitable country or area where the process could be tried out.

An economic evaluation of the process was attempted in 1969 by applying commercial costing to data from Ceylon. This indicated that the process was likely to be unprofitable, although the result was considered by its author to be inconclusive owing to the inadequacy of the available information about Ceylon. In February 1971 a renewed effort to obtain economic information for the purpose of evaluating the project was initiated by the despatch of a questionnaire to Jamaica, Ceylon, Thailand, the Philippines and Fiji.

A complete answer was received in August 1971 from Ceylon and another from Jamaica in December 1971. Although this study was started in September 1971, the material from Ceylon was not used initially because the information on the cost of making copra was incomplete, and because it appeared less adequate for

(1) MINISTRY OF OVERSEAS DEVELOPMENT: TROPICAL PRODUCTS INSTITUTE, 1970.
Report of the Tropical Products Institute 1968-69. London: TPI, p.41.

a full evaluation than material collected by one of the writers in Malaysia during 1971. The latter was supplemented by two detailed and relevant reports which were available in UK ^{(2),(3)}.

THE METHOD

It was decided to compare the costs of the traditional copra process and the TPI 'wet coconut' process using Malaysian factor costs. Further reasons for the choice of Malaysia in addition to those cited above were that Malaysia is a significant producer of coconuts, being sixth in the world in order of size of production, and that the rate of inflation is said to be only about one per cent per year which facilitates the use of data spread over a small range of years without elaborate adjustment ⁽²⁾. It was also thought that the selection of Malaysia would lead to a rapid analysis of the cost structures, enabling comparisons to be made using various assumptions.

The possible choice between the processes exists because they both use the same resource of coconuts. Therefore the comparison was made on the basis of inputs of equal quantities of the raw material in order to make the costs of the two processes directly comparable in terms of the common factor.

Since international prices were available for the major inputs and outputs and since information on factor inputs in Malaysia was available, it was relatively easy to apply the OECD system of social cost benefit analysis ⁽⁴⁾. In an evaluation of this type where the aim is to identify general economic characteristics of the industry applicable in a wide range of countries it is necessary to use such a method which eliminates distortions in the cost structure which arise from peculiarities of national systems of taxation and from the imperfection of factor markets in different countries, and which would appear in conventional commercial cost comparisons.

ASSUMPTIONS AND PROCEDURE

The scale chosen for operations in the models was ten tonnes of copra per day, or the equivalent in fresh coconut (49,000 nuts), which has been described as 'medium' scale for the copra process ⁽⁵⁾. Both commercial costings (excluding company taxation) and social costs have been derived for each process. The probable revenues from the processes were then worked out and finally the costs and revenues were subjected to discounted cash flow analysis to derive comparable results in terms of net present values. These cost and revenue analyses are set out in Tables 1-4 and their calculation is described in the Notes to the Tables.

The equivalence between the inputs of fresh meat from 49,000 nuts and ten tons of copra needs further explanation. Considerable waste may result from inefficient processing, transport and storage of copra. As much as ten per cent may be lost in the drying stage and a further five to ten per cent from insect or rodent attack during storage and transportation. Further, badly dried copra yields oil with a high f.f.a. content which causes losses of from five to ten per cent of the crude oil produced during the refining stage ⁽⁶⁾. All these losses are avoided in the wet-coconut process.

(2) LITTLE, I.M.D. and TIPPING, D.G. 1970. *A social cost-benefit analysis of the Kulai Oil Palm Estate, West Malaysia*. Oxford: Nuffield College (unpublished report).

(3) SELVADURAI, S. 1968. *A preliminary report on the survey of coconut small-holdings in West Malaysia*. Kuala Lumpur: Ministry of Agriculture and Co-operatives.

(4) LITTLE, I.M.D. and MIRLEES, J.A. 1969. *Manual of industrial project analysis in developing countries. Vol. II, Social cost-benefit analysis*. Paris: OECD.

(5) THIEME, J.G. 1968 Coconut oil processing. *FAO Agricultural Development Paper* No. 89. Rome: FAO, p. 172.

(6) TIMMINS, W.H. 1970. A process for the extraction of protein and oil from fresh coconut. M. Tech. Thesis, Loughborough University, June 1970, p.3.

However this desirable characteristic is counter balanced by a rather low oil extraction rate. Both sets of characteristics are reflected in the assumed inputs and outputs. Thus, according to an FAO source quoted by the TPI statistician, 4,900 nuts are required in Malaysia to yield one tonne of copra, which yields on average 600kg of oil. Another source⁽⁷⁾ implies that 4,500 Malaysian nuts yield one tonne of copra containing 660kg of oil. If both these input-output ratios are accepted, it can be said that 4,900 Malaysian nuts contain 718kg of oil of which only 600 are extracted, resulting in a wastage of 16 per cent up to the produce of the expeller. According to information supplied by TPI technologists the meat from 4,900 coconuts yields 600kg of oil, which in relation to an assumed 718kg contained in the nuts implies an extraction rate of only 84 per cent of the weight of the raw material. In the case of the copra process, 400 nuts or eight per cent of the meat is wasted before the copra reaches the expellers. Since the f.f.a. content of the oil produced by the wet-coconut process is necessarily one per cent or less it may command a premium over the oil produced by the expeller process. This is taken account of in the evaluation.

It must be stressed that wastage is not inherent in the copra process. It has been observed in Ceylon that copra made on the same premises as the oil mill and used without delay yields oil with as low an f.f.a. content as the wet-coconut process. The yield of oil from the expeller process can also be as high as 96 per cent⁽⁸⁾. However, the input-output ratio assumed here which happens to be equal to that claimed for the wet-coconut process, is realistic for Malaysia.

This evaluation was initially undertaken prior to a visit by Dr D A V Dendy of TPI to Ceylon in December 1971, when he discovered that oil of equally high quality can be made by the expeller process, provided that the copra is well dried and used without delay. Another fact which emerged in the course of the study was that good copra can be made more cheaply than bad copra by the use of efficient drying methods. Since the export of copra is remunerative the low cost manufacture of good copra is likely in a competitive situation to drive up the price of fresh coconuts. Both these features of the coconut situation convey advantages to the copra-expeller process, vis-a-vis the wet-coconut process.

Prices for machinery and equipment for both processes were available for 1970 to early 1971. Actual average wages and salaries published in 1969 were used and appeared to tally with those recorded in 1971. Prices of inputs of raw materials and products have been varied as explained in the notes to Table 2 & 3. The base year is thus approximately 1970 and all values are expressed in sterling.

The social accounting approach was greatly facilitated by the loan of a report of a project evaluation done in Malaysia in which the OECD system had been applied, and in which shadow wage and other conversion factors had been estimated⁽⁹⁾. Another fortunate circumstance was the availability of a very detailed economic study of small-holder coconut production in Malaysia⁽¹⁰⁾.

Table 1 shows capital costs for both processes. The compilation of this table posed no major problems beyond those described in the notes. The factories were assumed to be situated at ports, so that items for which international costs were appropriate could be priced at the same level for both commercial and social calculations. Details of the plant required for both processes is given in Appendix 1.

(7) UNITED COCONUT ASSOCIATION OF THE PHILIPPINES 1970. *Coconut Statistics 1970*. VI. Manila: UCAP, p. 207.

(8) Ministry of Plantation Industries, Ceylon (private communication).

(9) LITTLE, I.M.D. and TIPPING, D.G. 1970 *A social cost-benefit analysis of the Kulai Oil Palm Estate, West Malaysia*. Oxford: Nuffield College (unpublished report).

(10) SELVADURAI, S. 1968. *A preliminary report on the survey of coconut small-holdings in West Malaysia*. Kuala Lumpur: Ministry of Agriculture and Co-operatives.

No allowance has been made for provisions to prevent pollution which might, according to a private communication, increase the capital cost of the wet coconut process by as much as a third. A similar cost would be incurred if oil were derived by the expeller process from copra made from fresh coconut on the premises.

Table 2 shows operating costs for the two processes. Both sets of costs were calculated on the assumption that the respective plant operated continually at full efficiency.

In an efficient copra mill there is a necessary loss of operating times of the order of one per cent for maintenance, which may be increased in an inefficient mill and nothing is known about levels of efficiency in the wet-coconut process. Any arbitrary allowance for lost time in this calculation would therefore have to affect each process in equal proportion so that the assumption of 100 per cent efficiency does not affect any conclusions, and considerably eases computation.

A major difficulty encountered in compiling this table concerned the pricing of fresh coconuts. Insufficient information was available for the adoption of an internal price for fresh nuts, and the international or 'border' price could not be used since the fresh coconuts which are marketed overseas are selected for quality so that their price is not typical. The procedure that was finally adopted was to take the border price for copra as the fixed point and to work back to the fresh coconut price by deducting an allowance for copra making and by adding a sum to take care of the extra cost of transporting whole nuts above the cost of copra transportation. It might also be noted at this point that the accounting or social value of copra is higher than the commercial value on account of the ten per cent *ad valorem* duty imposed on exports of copra whose incidence falls on the copra producers. Since the border prices for copra used in the calculation are based on actual transactions, they have the advantage of taking account of any seasonal fluctuations in prices.

Columns d to i of Table 2, reflect different assumptions affecting the operation of the wet-coconut process. In columns d and e, the price of coconuts is assumed to be considerably reduced as the effect of inefficient and costly copra making by small-holders. Alternative transport costs are inherent in the small-holder situation since other copra or nuts must be brought from collecting points to any processing factory. In columns f to i, it is assumed that copra is normally made efficiently at low cost on estates. Here, the alternative exists for estates either to sell nuts to a wet-coconut factory elsewhere so that the price of nuts would be affected by a transport differential as shown in columns f and g, or to set up wet-coconut processing on the estate in which case there would be no transport differential (as in columns h and i) and the nuts would be cheaper.

In the case of the wet-coconut process it is not possible to be certain about the validity of some of the input coefficients since production has not taken place at this scale, therefore some figures, for example those for inputs of chemicals and power are very approximate.

No allowance has been made for unforeseen expenses in Table 2, both because an estimate would have equal effect on both processes and because a high proportion of the total operating cost is accounted for by the raw material cost which is subject to variations of a size that would be as great as any realistic allowance for unforeseens.

Table 3 shows probable revenues from the sale of the output of the processes. In the case of coconut oil and cake higher and lower prices were used. In the case of coconut oil and cake, two sets of prices were used. The first reflects the relatively high prices in effect in the years 1968 to 1969, and the second the lower average prices in effect over a longer period. In the case of charcoal which is a by-product of the wet-coconut process, a single price was taken on the basis of information about international prices.

Since protein of vegetable origin is not imported into Malaysia, there was no readily available border price for this product. Finally, an international price was estimated on the basis of a quoted price for defatted groundnut flour as explained in note 3 on page 20.

Tables 4A and 4B show the results of the application of discounted cash flow analysis to the data described above. The arrangement of the columns is related to that in Table 2. Additional rows have been included in Tables 4A and B in order to examine the effect of varying certain parameters that were thought to be significant. These include capital cost, raw material cost and a premium price for oil. In each case the inflows less outflows over a period of 15 years are discounted at a rate of eight per cent which, in the absence of any direct data about the scarcity of capital in Malaysia, is taken as the expected social rate of return. The figure yielded by this calculation, called the Net Present Value (NPV), gives the relative benefit accruing from the process under the various assumptions. In order to make direct comparisons between the copra process and the wet-coconut process the incremental cash flow or the difference between the cash flows is discounted in a similar manner in order to avoid difficulties caused by differences in the absolute magnitudes of the different costs.

RESULTS

The principal results that are shown in Table 4B are that there are only positive net present values for the wet-coconut process on an accounting cost basis in one column f, and only when high prices are assumed (rows 10 and 11, ii). The net present values present value given in column f are higher than that given in the copra process, column c, row 11 of Table 4A.

It can be seen that the results are sensitive with respect to the price received for oil and to the cost of the raw material, copra or coconuts, which account for about 90 per cent of total operating costs. In particular it is evident that the high net present values indicated in column f are a result of the high cost of copra drying assumed in this column, which has the effect of lowering the value of the raw material.

The difference in the results between columns g and h, and columns i and j of Table 4B — the wet-coconut process — is a reflection of sensitivity to relative transport costs for coconuts and for copra. Though the omission of the transport cost differential and the resulting lower estimated coconut price improves the position of wet-coconut processing it does not under this assumption become competitive with the copra process as shown in Table 4A. This suggests that the wet-coconut process is likely to be beneficial only in a country where copra drying is inefficient. It could be argued, however, that to improve the efficiency of the existing copra industry would cost less. The knowledge of better methods of copra production in Malaysia and the Philippines, has nevertheless failed to benefit small-holders who lack incentive because of the marketing structure which ensures that they receive a low proportion of the export value of copra⁽¹¹⁾. Again, the correct strategy, apart from Government intervention in the marketing system, would appear to be for copra producers co-operatives to invest in expellers to process their own copra.

A major objective of the wet-coconut project was to obtain protein from coconuts. Given that, at the price taken, protein is only five to ten per cent of total sales receipts, the extra capital cost incurred to extract the protein may not be the best use of resources in this direction. This is partly a reflection of the low protein content of coconut in comparison with, say, cottonseed, soybean or groundnut⁽¹²⁾. Moreover, at the present time the market for pure protein extract is undeveloped, and there are few cases in developing countries where this protein has gained a substantial entry into the market.

(11) UNITED NATIONS ECAFE 1969. The coconut industry of Asia.

Regional plan harmonization and integration studies series, No. 1. New York, UN, pp. 31–32.

(12) FOOD AND AGRICULTURE ORGANIZATION 1964. Protein. *FAO World Food Problems*, No. 5.

Revised: FAO, p. 13.

The coconut industry of Ceylon is relatively efficient and highly organised with generally high quality copra and oil being produced. Wage levels, on the other hand are very low, (less than half those of Malaysia) and this factor might have tended to favour the establishment of wet-coconut processing. A costing exercise, on the lines of the Malaysia model described above, was carried out. The results showed negative cash flows in all the cases investigated, for both the copra and wet-coconut processes, though much greater in the latter case. The negative cash flow in the case of the copra process illustrates the advantage of exporting copra over the export of oil, a reflection of the tariff structures of the principal markets, and, in the case of Ceylon the ready market for copra in India. For the purposes of the present paper the most interesting conclusion is that the existence of a low wage economy does not favour the wet-coconut process in the presence of efficient copra making.

The Jamaica Coconut Industry Board, buys all copra produced on the island and sells it to the two coconut products factories. No copra and only negligible quantities of oil and coconuts are exported, so that it was not possible to use the fob values of exports of copra and oil as a basis for social accounting. In view of the integrated nature of the industry, prices for fresh coconuts and copra quoted by the Board could be regarded as reliable and were used in a commercial cost comparison. The comparison corresponds with the one made for Malaysia and shown in columns b and c with h and i of Table 2, in which low copra drying costs and no transport differential are assumed. The cost of drying is in fact high in Jamaica because the wages of unskilled labour are about three times as high as in Malaysia. However the methods used are efficient. The coconut is delivered to the dryer in the form of husked nuts so that there is no transport differential. The price per tonne of copra which is of high quality is £84.6 and the cost of nuts equivalent to one tonne of copra is £64.05. The internal price of crude oil is £192.4 per tonne and is maintained at a level above the international price for good quality unrefined oil by a tariff and possibly import restrictions. Costings based on these input and output values and Jamaica factor costs yielded net cash flows before tax of £97,000 for the copra process and £81,000 for the wet-coconut process, the capital costs being £81,000 and £131,000 respectively. The commercial results for the copra process are thus appreciably better than those for the wet-coconut process and there is no factor which would cause the order in social accounting terms to be reversed. Social accounting might however reveal that the processing of copra into oil is less beneficial to Jamaica, than the export of high grade copra would be.

CONCLUSIONS

At first sight it might appear, in situations where the drying of copra by small-holders is inefficient and costly (so driving down the price of fresh nuts) and where a premium on the home market might accrue to the high quality oil produced by the wet-coconut process, that the latter process would have an economic advantage over the copra process. But we now know that it is also possible to make high quality oil by the expeller process using fresh copra made on the premises from husked nuts. This alternative is available even to small-holders themselves via their co-operatives. To express this point in terms of this evaluation the true comparison in Tables 4A and B is not between the copra process (columns b and c) and the wet-coconut process in columns e and f but between the copra process and columns i and j. The returns on the copra process would be above the levels shown in rows 2 and 3 of Table 4A because of the premia on good quality oil amounting to £12,800 and £14,400 respectively, but there need not be any increase in operating cost because it does not cost more to make good quality copra. If the premium on good quality oil had been added to the receipts for the expeller process, the advantage of the latter would increase. Economies of scale also operate in favour of the expeller process, so that there would be no advantage in running a small scale wet-coconut process close to the origin of the nuts.

Given the low cost of available alternative sources of vegetable protein, the low yield of four per cent of edible protein on the weight of fresh coconut meat is of little value. Indeed under certain valid assumptions as to the yield of oil on both processes the total revenue from oil and cake for the expeller process can be higher than that for oil and protein from the wet-coconut process. Its apparently low oil yield is a disadvantage to the wet-coconut process. It is claimed to be about 85 per cent of the oil in the nut, whereas in good conditions in Ceylon 96 per cent of the oil in copra can be extracted by the expeller process. The rate assumed in the evaluation for Malaysia based on a technologist's statement was about 84 per cent. It is believed that an extra five per cent could be extracted by remilling the residues, which would double the capital cost and increase the operating cost. However, the extraction rate has so far only been estimated from short run experiments and cannot be established accurately without long-run pilot experiments, which in view of the raw material supply would have to be carried out overseas.

Another conclusion that can be drawn from Table 4A is that the coconut oil processing industry in developing countries is not a very profitable one, since row 6 shows that when low average oil prices are assumed the net cash flow is negative both in commercial and in accounting terms. This is consistent with the high level of unused processing capacity in Asian countries⁽¹³⁾ and with the fact that in several countries production of coconut is being reduced. The low profitability of coconut oil processing in developing countries is connected with the high level of protection given by advanced countries where the effective tariff on copra is often 100 per cent of the value added while the protection given to oil refining is even higher⁽¹⁴⁾ and copra is admitted duty free; a situation which showed no sign of improvement at the time of the Kennedy Round in 1967⁽¹⁵⁾. The effect of this tariff structure is to encourage the export of copra rather than oil.

The FAO projection published in *The coconut industry of Asia*, which predicts continuing high prices, is based on trends existing towards the end of the seventies and does not take account of the new plantings in the Philippines which caused a fall in prices after 1970; copra prices in February 1972 reaching the lowest level since 1957⁽¹⁶⁾. The coconut situation is thus not favourable towards large investments in the industry, and there is not a clear case for setting up a pilot plant for the wet-coconut process designed to produce only oil and protein. If, however, it can be established that stable coconut cream can be produced by modifying the existing process, it might be possible to justify the establishment of a pilot plant for the purpose of test-marketing a new product for which there is no close substitute, as well as to validate many of the assumptions made in this calculation.

(13) UNITED NATIONS ECAFE 1969. *The coconut industry of Asia. Regional plan harmonization and integration studies series*, No. 1. New York: UN, pp. 36–37.

(14) Ibid. p.87.

(15) Ibid. p.67.

(16) Financial Times, 25th February, 1972.

Table 1
Capital Costs
£ sterling 1970

B Wet coconut process					
A Copra process					
	Items and prices	Commercial value	Accounting value	Items and prices	Commercial value
	a	b	c	d	e
					f
1	Land 0.5 acre (2,025m ²) at £3,400 per acre	1,700	1,040	Land 0.5 acre (2,025m ²) at £3,400 per acre	1,700
2	Factory building, 288m ² at £19 per m ²	5,470)	—	Factory building, 185m ² at £19 per m ²	3,520)
3	Storage building 288m ² at £19 per m ²	5,470)	7,850	Storage building 986m ² at £19 per m ²	18,730)
4	Copra drying floor 450m ² at £1,595 per acre (4,050m ²)	180)	—	Charcoal kilns, 8 at £215.5	1,720
5	Machinery and plant including spares and boiler cif	21,040	21,040	Machinery and plant including spares and boiler cif	31,800
6	Allowance for installation and unforeseens 15% on row 5	3,160	3,160	Allowance for installation and unforeseens 15% on row 5	4,770
7	Total fixed capital	<u>37,020</u>	<u>33,090</u>	Total fixed capital	<u>62,240</u>
8	Working capital	18,700	18,950	Working capital	19,480
				i columns (d) & (e) of Table 2.	19,400
				ii columns (f) & (g) of Table 2.	20,260
				iii columns (h) & (i) of Table 2.	19,930
9	Total investment	55,720	52,040	Total capital	81,700
				i columns (d) & (e) of Table 2.	74,350
				ii columns (f) & (g) of Table 2.	74,270
				iii columns (h) & (i) of Table 2.	74,070

Footnotes:

— not applicable
---- subtotal

NOTES ON TABLE 1

A. The copra process

1. Land:

For a rural mill processing eight to ten tons of copra per day a total area of 3,000 to 5,000 square metres of land has been suggested ⁽¹⁷⁾. In the cost model the mill is assumed to be in an industrial estate where land is comparatively expensive, so an area of 0.5 acres has been taken. The commercial cost per acre has been based on the actual price paid by a mill on such an estate. The accounting value has been derived in two stages. First the price paid for the undeveloped land by the industrial estate ⁽¹⁸⁾ has been adjusted to take account of the 10 per cent duty on copra and rubber which represent the alternative use of the land, the return from these crops being the opportunity cost of the land. Secondly the cost of developing the land has been taken, and to this the breakdown ratios for the construction industry have been applied and the results multiplied by the appropriate conversion factors ⁽¹⁹⁾. The sum of these two calculations gives the social cost of the land.

2/3. Buildings:

The size of the factory and storage building are given by Thieme. It has been assumed that the raw material is stored to a mean level of three feet, approximately the height at which such material can be tipped from lorries. The commercial costs of the buildings were taken from an actual factory on the industrial estate, and the accounting costs were derived by the method given in Little and Tipping. The calculation is shown below ⁽²⁰⁾:

Commercial value £	Breakdown ratios	Estimated components £	Conversion factors	Accounting values £
a	b	c = a x b	d	e
	wages 0.240	2,669	0.231	617
	salaries 0.056	623	0.9	561
	profit 0.194	2,157	0.65	1,402
	taxes 0.036	400	—	—
	foreign exchange 0.474	5,271	—	5,271
11,120	1.000	11,120		7,851
				residual 3,269
				11,120

4. Drying Floor:

Thieme gives the size of drying floor needed for a factory of this size. The price of concrete was obtained in Malaysia.

5. Plant:

The cost early in 1971 of an oil mill with two Maxoil expellers and ancillary equipment to process eight to ten tons of copra per day was given by Rosedowns and Thompson. To this was added the cost of an oil fired boiler. As the shipping measurement was not known, insurance and freight were roughly estimated at six per cent on the fob. This figure was taken from a private report on a palm kernel mill in West Malaysia.

(17) THIEME, J.G. 1968. Coconut oil processing. *FAO Agricultural Development Paper* No. 89. Rome: FAO, p.173.

(18) MALAYSIA INDUSTRIAL FINANCE BHD 1968. *Sites for industry*. Kuala Lumpur.

(19) LITTLE, I.M.D. and TIPPING, D.G. 1970. *A social cost-benefit analysis of the Kulai Oil Palm Estate, West Malaysia*. Oxford: Nuffield College (unpublished report).

(20) *Ibid.* pp.24–26, 68.

6. *Contingencies:*

Conventional allowance.

8. *Working Capital:*

The estimate for working capital was based on the same private report and includes the following items: ten days' copra, six days' oil, six days' cake; receivables equal to the sum of the latter two items and one month's working expenses derived from Table 2.

B. **The wet-coconut process**

1. *Land:*

The same assumptions and calculations have been made as in the case of the copra process.

2. *Factory:*

The area of the factory building was taken from information supplied by W Timmins.

3. *Storage:*

The storage area was calculated on the basis of 80 cubic feet per ton, on the assumption that the nuts were stored to a mean height of three feet, and assuming that ten days supply would be stored. The figure yielded amounts to a high proportion of the total capital invested (about 30 per cent), and sensitivity analysis was carried out to examine the effect of lowering the cost of storage, for which see Table 4, rows 10 and 11.

4. *Charcoal kilns:*

The commercial price of the steel charcoal kilns was based on the price obtaining in Uganda⁽²¹⁾. A TPI engineer thought that the price in Malaysia of locally made kilns would be comparable to that in Uganda, though considerably above the ex-factory price in the UK. It is assumed that the kilns have a useful life of only three years.

5. *Plant and Machinery:*

The cost given in this line is based on quotations given to W Timmins by machinery manufacturers in 1970, plus an allowance of 6 per cent for transport, insurance, etc.

6. *Contingencies:*

Since the estimates for land and building are realistic and ample the allowance of 15 per cent for installations and unforeseens is restricted to the value of machinery.

8. *Working capital:*

The assumptions on which the estimate of working capital is based are similar to those used for the copra process except that a normal stock of 14 days output of charcoal is assumed.

(21) EARL, D.E. 1970 (revised). The mark V portable steel kiln. *Uganda Forestry Department Technical Note*, 164/70, p.1.

General

The input-output ratio used in the calculation were given by TPI Statistics Section from an FAO source relating to Malaysia and are as follows:
 4,900 coconuts yield one tonne of copra.
 8,000 coconuts yield one tonne of oil.
 coconut weighs 0.7 kg.

According to Table 20 of the Selvadurai report, a sample survey showed that on average 4,430 nuts yielded one tonne of copra⁽²²⁾. The assumption that 4,900 nuts are needed thus allows for a ten per cent loss through spoilage during the drying stage⁽²³⁾. D A V Dendy is of the opinion that the yield of oil in the wet-coconut process will be the same as quoted above.

A. The copra process

1. Copra:

The accounting price for copra has been calculated from the weighted average of export prices from Malaysia for 1968-69, shown in Table 5. Since there is a ten per cent *ad valorem* export duty on copra, the commercial value is derived by dividing the accounting value by a factor of 1.1.

5. Filter cloths:

These are assumed to be imported from Europe. The rate of usage and price were taken from a private source in the Philippines. Being expressed in international prices, commercial and accounting values are the same.

10/18. Personnel:

The numbers of factory personnel were derived from an FAO report⁽²⁴⁾. The number required in the office was estimated. Commercial salaries and wages were taken from a Malaysian report and were in accordance with rates collected privately in 1971⁽²⁵⁾. The conversion factors taken from Little and Tipping were 0.231 for unskilled labour and 0.9 for salaried employees.

19. Electricity:

Consumption was calculated on the basis of 85HP for the expeller process and 80HP for the wet-coconut process. The standard conversion factor of 0.9 was applied to arrive at the accounting value.

20. Steam:

It is assumed that the steam is raised by means of a diesel-fuelled boiler. The calculation of fuel requirements was made in consultation with TPI engineers and the price obtained from a firm in Malaysia, net of tax for the accounting value.

(22) SELVADURAI, S. 1968. *A preliminary report on the survey of coconut small-holdings in West Malaysia*. Kuala Lumpur: Ministry of Agriculture and Co-operatives, p.52.

(23) TIMMINS, W.H. 1970 A process for the extraction of protein and oil from fresh coconut. M. Tech. Thesis, Loughborough University, June 1970.

(24) THIEME, J.G. 1968. Coconut oil processing. *FAO Agricultural Development Paper* No. 89, Rome: FAO, p.73.

(25) FEDERAL INDUSTRIAL DEVELOPMENT AUTHORITY, KUALA LUMPUR 1969. *Labour and wage rates*. Kuala Lumpur: FIDA, last page.

21. *Water:*

The water requirements are based on the figure of 60 gal per hour per expeller. A conversion factor of 0.7 which equals the ratio between the accounting value and the commercial value for construction was applied to the commercial value for water.

22. *Maintenance:*

The commercial figure for maintenance materials was derived from a copra mill in the Philippines, and has been allocated on the basis of HP without any further adjustment. The accounting value was derived by applying the general conversion factor 0.9.

23/24. *Insurance:*

Insurance rates were quoted by a firm in Kuala Lumpur and were converted by the factor 0.9.

B. The wet-coconut process

1. *Copra:*

The same calculation is made as in the case of the copra process. The price of fresh coconuts was not taken as the base for the reasons given in the text. It may be noted that it would have been more difficult to calculate social costs for the coconuts on the basis of input data if the latter had been available.

2. *Transport:*

It was assumed that the proposed factory would be sited on the coast near Penang in Malaysia, and that the coconuts would be provided by producers in the Selangor/Perak area as given in the Selvadurai report. It was roughly assumed that both copra and fresh coconuts would have to travel an average distance of 25 miles from producer to factory, which would involve a round trip of 50 miles. This was costed at M¢ 20 per tonne mile. The coconuts would cost 3.43 times as much as the copra. The difference between the two resulting costs is given in the table. The accounting cost of the transport has been calculated by applying the Little and Tipping conversion factor to the results yielded above.

3. *Copra drying:*

Two different bases are used for calculating the cost of drying copra to arrive at the figure to be deducted from the international cost of copra to arrive at alternative realistic costs for fresh coconut. In columns c and d a relatively high cost of drying copra is derived from Tables 75 and 78 of the Selvadurai report. The ratio of copra manufacturing cost to total cost shown in Table 78 was applied to the information for Selangor/Perak given in Table 75, yielding a figure of £7.1 per tonne.

On page 92, Selvadurai says that copra of standard quality should only contain 5 or 6 per cent moisture, but that the copra produced by small-holders contains twice that amount. Middlemen dry it down to the required level before it reaches the mills. A rough adjustment of £4.82 per tonne has been made to allow for this additional drying cost. The resulting figure of £11.92 is multiplied by 1.051 to allow for one per cent inflation per annum to give an estimate of £12.53 for 1970. To arrive at the accounting value for copra drying, the general conversion factor of 0.9 quoted by Little and Tipping has been used since this is appropriate both for labour in subsistence agriculture and for the capital equipment involved.

In the remaining columns the cost of copra drying has been derived from more recent material ⁽²⁶⁾. Here, the accounting value is calculated by the use of Little and Tipping

(26) McCULLOCH, G.C. 1968. The economics of coconut monoculture planting in Malaya. *Cocoa and coconuts in Malaya*. Kuala Lumpur: Incorporated Society of Planters, p.97.

conversion factor of 0.231 for unskilled labour in the industrial sector.

4. *Coconut input:*

The estimated value of fresh coconuts was derived by subtracting row 2 from row 1 and adding row 3.

6/7. *Chemicals:*

The figures used to compute the input of chemicals were supplied by W Timmins. It is possible to substitute various acids and solvents for each other, so an attempt has been made to choose the cheapest chemicals available, available, by making use of chemical producers' price lists. The optimum input pattern can only be determined by operational experiment. An allowance of six per cent was made for insurance and freight. The commercial and accounting prices are the same.

8. *Charcoal bags:*

The charcoal bags are assumed to have been made locally and the commercial value is the ex-factory price. The general conversion factor of 0.9 has been applied to derive the accounting value.

10/18. *Personnel:*

The labour complements have been discussed and agreed with W H Timmins. The number of handling labourers is based on the rule-of-thumb that in the absence of a complete mechanical handling system one operative is required per ton of input per day. These operatives are assumed to deal with nuts arriving in the mill and the shifting and storage of products, especially the shells which have to be transported from the nut shelling station to the charcoal kilns. The number of nut-shellers is based on the stated average output per man-shift for a desiccated coconut factory in the Philippines which is 1,200 nuts. The number has been rounded to 42 which is divisible by 3 (shifts). The number of charcoal labourers was derived from the Uganda report ⁽²⁷⁾. Two men are required to load four kilns on alternate days (the whole process of carbonisation and cooling taking from 24 to 36 hours) so it was assumed that the same number of men working each day could look after 8 kilns. In view of the larger number of personnel to be dealt with, the number of office workers was increased by one.

19/21. *Services:*

Estimated inputs were supplied by W H Timmins. Costs were calculated in the same manner as for the copra process.

22. *Maintenance:*

Calculated on the basis of five per cent of the cost of the plant, that is, by the conventional rule-of-thumb.

23/24. *Insurance:*

Calculated on the same basis as used for the copra process.

(27) EARL, D.E. 1970 (revised). The mark V portable steel kiln. *Uganda Forestry Department Technical Note*, 164/70, pp.3-4.

Table 3(a)

Receipts

£ Sterling 1970

A. Copra process

	Receipts	Commercial values	Accounting values
	a	b	c
	<i>Low price assumption</i>		
1	Oil (0.6 of weight of copra) = 6 tonnes per day at £95 per tonne	171,000	171,000
2	Cake (0.33 of weight of copra) = 3.3 tonnes per day at £26 per tonne	26,000	26,000
3	Total, low price assumption	<u>197,000</u>	<u>197,000</u>
	<i>High price assumption</i>		
4	Oil as row 1 @ £124 per tonne	223,200	223,200
5	Cake as row 2 @ £31.38 per tonne	31,380	31,380
6	Total, high price assumption	<u>254,580</u>	<u>254,580</u>

Table 3(b)

Receipts

£ Sterling 1970

B. Wet-coconut process

	Receipts	Commercial values	Accounting values
	d	e	f
	<i>Low price assumption</i>		
1	Oil, 6 tonnes per day @ £101 per tonne	181,800	181,800
2	Oil, 6 tonnes per day @ £95 per tonne (no premium)	171,000	171,000
3	Protein 0.424 tonnes per day @ £122 c.i.f.	15,500	15,500
4	Charcoal 2.49 tonnes per day @ £15 f.o.b.	11,200	11,200
5	Total, premium on oil	<u>208,500</u>	<u>208,500</u>
6	Total, no premium on oil	<u>197,700</u>	<u>197,700</u>
	<i>High price assumption</i>		
7	Oil, as row 1 @ £132 per tonne	230,600	230,600
8	Oil, as row 2 @ £124 per tonne (no premium)	223,200	223,200
9	Protein, as row 3	15,500	15,500
10	Charcoal, as row 4	11,200	11,200
11	Total, premium on oil	<u>257,300</u>	<u>257,300</u>
12	Total, no premium on oil	<u>249,900</u>	<u>249,900</u>

NOTES ON TABLE 3

A. The copra process

3. Oil:

The value of the oil is taken from the weighted average of fob values for Malaysian exports for 1968 and 1969, shown in row 2 of Table 5. As there is no export duty on coconut oil, the accounting value is the same as the commercial value. For the purpose of this calculation an oil yield for 60 per cent of the weight of copra has been adopted, which is the figure quoted by an ECAFE report referring to the output of relatively large and modern oil mills in Malaysia⁽²⁸⁾.

4. Cake:

The price of the cake exported is also taken as the weighted average of Malaysian exports for 1968 and 1969. The yield of the cake is as stated by Thieme⁽²⁹⁾.

1. Oil:

Since the price of oil used in row 3 is comparatively high, and is taken over a comparatively small period of time, a second set of calculations have been made which are based on the weighted average of coconut oil export prices from Malaysia over the ten year period 1960 to 1969. In other respects the notes to row 3 apply.

2. A similar procedure was adopted to that explained for row 1.

B. The wet-coconut process

1/2. Oil:

The yield of oil taken is based on information provided by TPI technologists, and is so close to that used for calculations for the copra process as to be identical. In the calculation in row 1 it is assumed that the product of the mill would be sold in the home market where it would command a premium price on account of its high quality, which approaches that of a refined oil. In 1969 Unilever stated to a member of TPI that they would be prepared to pay a premium of £8 per tonne for such oil delivered to the UK market. Accordingly the sum of £8 per tonne has been added to the high oil prices and £6 per tonne to the low oil prices derived in the manner described for the copra process. The calculation in row 2 is identical with that in row 3 of the copra process.

3. Protein:

According to TPI technologists the protein isolate produced by this process contains 80 per cent of pure protein and 0.088 tonnes of protein isolate are yielded per tonne of oil. The daily output of pure protein can be estimated as follows:

$$6.027 \times 0.088 \times 0.8 = 0.424 \text{ tonnes pure protein}$$

Marketing Section of TPI provided a series of 1970 prices for various protein products. The one selected for use in this study was 11 to 12p (f.o.r. Bombay bulk packed) per kg of pure protein in defatted groundnut flour containing 55-60 per cent of protein. An arbitrary estimate of 6 per cent for freight and insurance was added to yield an estimated cif value of £122 per tonne which was used in both commercial and social accounts.

(28) UNITED NATIONS ECAFE 1969. The coconut industry of Asia. *Regional plan harmonization and integration studies series*, No. 1. New York: UN, p.38.

(29) THIEME, J.G. 1968. Coconut oil processing. *FAO Agricultural Development Paper* No. 89, Rome: FAO, p. 172.

4. *Charcoal:*

The 14.7 million shells per year are assumed to yield 747 tonnes of charcoal⁽³⁰⁾. An fob price of £15 per tonne was assumed after inspection of data from Ceylon and the Philippines relating to exports and in the latter case freight rates^{(31), (32), (33)}.

7/12. In this set of calculations the price of oil has been calculated in the way described in row 3 of the copra process. All other parts remain as in the low price assumption.

(30) CEYLON COCONUT RESEARCH INSTITUTE 1965. Coconut shell charcoal. *Ceylon Coconut Research Institute Leaflet No. 266*, p.4.

(31) *Ceylon Trade Journal* 1970. 35 (8-12), p.167.

(32) *United Coconut Association of the Philippines Weekly Bulletin* 1971. 6 (31), pp. 21-23 and 6 (33), pp. 18-20.

(33) UNITED COCONUT ASSOCIATION OF THE PHILIPPINES 1970. *Coconut statistics 1970*. VI. Manila: UCAP, pp. 31 and 89.

Table 4(a)

Discounted Cash Flows

£ Sterling 1970

Copra process

		Commercial		Accounting
		b		c
1	Capital cost	55,720		52,040
Total sales revenue				
2	(i) low price assumption	197,000		197,000
3	(ii) high price assumption	254,580		254,580
Total operating cost				
4	(i) low copra price assumption	200,810		213,590
5	(ii) high copra price assumption	227,100		242,490
Net cash flow (before tax)				
6	(i) row 2 - 4	-3,810		-16,590
7	(ii) row 3 - row 5	27,480		12,090
Net cash flow (after adjustment for consumption expenditure out of profits)				
8	(i)	-		-
9	(ii)	-		8,830
Net present value				
10	(i)	-		-
11	(ii)	180,070		23,570

Footnote:

- not applicable, net cash flow negative

Source:

See notes on Table 4.

Table 4(b)
Discounted Cash Flows
£ Sterling 1970
Wet coconut process

		d	High copra drying cost Transport differential		Low copra drying cost Transport differential		Low copra drying cost No transport differential	
			Commercial	Accounting	Commercial	Accounting	Commercial	Accounting
			e	f	g	h	i	j
1	Capital cost							
	(a) full storage (3' high for coconuts)		81,700	74,350	82,500	74,270	82,180	74,070
	(b) storage reduced (9' high for coconuts)		69,210	65,530	70,020	65,460	69,690	65,250
2	Total sales revenue							
	(i) low price assumption	A premium	208,500	208,500	208,500	208,500	208,500	208,500
		B no premium	-197,700	197,700	197,700	197,700	197,700	197,700
3	(ii) high price assumption	A premium	257,300	257,300	257,300	257,300	257,300	257,300
		B no premium	-249,900	249,900	249,900	249,900	249,900	249,900
4	Total operating costs							
	(i) low copra price assumption		194,580	204,760	218,660	225,470	208,820	219,320
5	(ii) high copra price assumption		220,860	223,650	244,960	254,370	235,120	248,220
6	Net cash flow (before tax)							
	(i) A. with premium, (row 3 - row 7)		13,920	3,740	-10,160	-16,970	-320	-10,820
		B. no premium, (row 4 - row 7)	3,120	-7,060	-20,960	-27,770	-11,120	-21,620
7	(ii) A. with premium, (row 5 - row 8)		36,440	33,650	12,340	2,930	22,180	9,080
		B. no premium, (row 6 - row 8)	29,040	26,250	4,940	-4,470	14,780	1,680
8	Net cash flow (after adjustment for consumption expenditure out of profits)			3,670	-	-	-	-
	(i) A. with premium		-	-	-	-	-	-
		B. no premium	-	23,960	-	2,930	-	7,300
9	(ii) A. with premium		-	18,940	-	-	-	1,680
		B. no premium	-	-	-	-	-	-
10	Net present value							
	(a) full storage capital costs (row 1)		33,760	-46,610	-	-	-	-
	(i) A. with premium		-58,660	-	-	-	-	-
		B. no premium	226,440	127,040	19,450	-52,900	103,900	-15,300
	(ii) A. with premium		163,100	84,070	-43,890	-	40,560	-62,400
		B. no premium	-	-	-	-	-	-
11	(b) storage reduced (row 2)		46,250	-37,790	-	-	-	-
	(i) A. with premium		-46,170	-	-	-	-	-
		B. no premium	238,930	135,850	31,940	-44,080	116,490	-6,490
	(ii) A. with premium		175,590	92,880	-31,400	-	53,150	-54,880
		B. no premium	-	-	-	-	-	-

Footnotes:

- not applicable, net cash flow negative.

Sources:

See notes on Table 4.

This table compares the wet-coconut process with the copra process, under different sets of assumptions. The assumptions have been varied in order that the sensitivity of the costs to changes can be examined and varied. The technique that is used in the table is that of comparing the Net Present Values of the processes under the different sets of assumptions. A discount rate of eight per cent is applied to the net cash flows over 15 years. The net cash flows are found by subtracting operating costs from sales revenues. The capital costs are deducted (discounted where necessary) from the discounted cash flows to yield the NPV.

Capital costs:

These are taken from Table 1. Two sets of capital cost have been used since in the initial wet-coconut calculation it was found that the cost of the storage building amounted to 30 per cent of the total capital invested, and it was likely that different conclusions would be reached if this figure could be reduced.

Sales revenue:

The source is Table 3.

Operating Costs:

The source is Table 2.

Net Cash Flow:

Sales revenue less operating costs.

Net Present Value:

Net cash flow discounted over 15 years at eight per cent, less discounted capital costs.

Table 5
Coconut Products - Exports from West Malaysia 1960-69

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
<i>Copra</i>										
1 Tonnes.....	114,810	109,210	38,290	26,560	6,390	16,270	12,850	2,810	3,590	2,510
2 US \$ tonne	182	142	145	160	169	206	181	190	188	176
<i>Coconut Oil</i>										
3 Tonnes.....	41,294	58,059	42,180	30,317	14,750	18,340	25,471	29,496	39,028	25,281
4 US \$ tonne	289	223	223	237	266	291	254	252	316	269
<i>Copra cake and meal</i>										
5 Tonnes.....	250	170	2,410	70	100	20	150	180	110	700
6 US \$ tonne	76	77	71	71	70	50	67	44	82	74
<i>Coconuts in the shell</i>										
7 Tonnes.....	3,665	6,085	9,043	7,422	15,575	10,204	3,603	3,998	2,817	3,479
8 US \$ tonne	60.6	50.9	51.0	44.9	48.0	49.5	43.3	35.0	35.0	31.0
9 '000 nuts (1) estimated	5,236	8,693	12,919	10,603	22,250	14,570	5,140	5,710	4,024	4,970
10 US \$ 1,000 nuts	42.4	35.5	35.7	31.4	33.6	34.7	30.4	24.5	24.6	21.7
<i>Unit value of exports</i>										
<i>Philippines</i>										
11 Copra (US \$ tonne)	172	141	145	163	172	192	167	167	192	171
12 Coconut oil (US \$ tonne)	263	214	215	267	290	289	242	259	306	254
<i>Total exports - by volume of copra equivalent</i>										
(tonnes)										
13 Copra	114,180	109,210	38,920	26,560	6,390	16,270	12,850	2,810	3,590	2,510
14 Coconut oil (2)	68,820	96,760	70,760	50,520	24,580	30,560	42,450	49,160	65,040	42,135
15 Coconuts in the shell (3)	1,068	1,174	2,637	2,164	4,541	2,973	1,049	1,165	821	1,014
16 Total	184,698	207,144	112,317	79,244	35,511	49,803	56,349	53,135	69,451	48,659
<i>Total exports - by value</i>										
('000 US \$)										
17 Copra	20,934	15,830	5,639	4,256	1,085	3,346	2,321	534	674	443
18 Coconut oil	11,912	12,880	9,410	7,190	3,929	5,342	6,467	7,455	12,330	6,803
19 Copra cake and meal	19	13	170	5	7	1	10	8	9	52
20 Coconuts in the shell	222	309	461	333	747	505	156	140	99	108
21 Total	33,087	29,032	15,680	11,784	5,768	9,194	8,954	8,137	13,112	7,406

Notes:

- (1) 1,000 nuts = 0.7 tonnes
(2) Exports of oil divided by 0.6
(3) 4,900 nuts = 1 tonne copra

Sources:

- (1) FAO Trade Yearbook 1963 (1960/62 figures).
Table 40, p.179; Table 55, p.249; Table 61, p.282;
Table 89, p.156.
(2) FAO Trade Yearbook, 1969 (1963/68 figures).
Table 46, p.181; Table 70, p.268; Table 88, p.320;
Table 118, p.411.
(3) FAO Trade Yearbook, 1970 (1969 figures).
Table 47, p.185; Table 73, p.282; Table 91, p.335;
Table 121, p.423.

Appendix: Equipment

1 Equipment for the copra process:

Magnet	
2 Rosedowns 15 HP Copra Grinders	
2 Rosedowns Maxoil Screw Presses	
2 Mild Steel Oil Gutters	
Mild Steel Settling Tank	
Rosedowns Filter Press	
Filtered Oil Tank	
Rotary Oil Pump	
Air Compressor	
Piping, valves, fittings	
Spares	
Conveyors and Elevators	
TOTAL	£19,000
Perkins Boiler including chimney, tanks etc.	£ 1,000
Miscellaneous spares, meters etc.	£ 1,000

2 Equipment for the wet-coconut process:

Slicer	
2 Mincemasters	
Slurry vessel	
Vibratory sieve	
Hydraulic press	
Dryer	
3 Creaming vessels of 1,000 gals	
1 Jacketed vessel of 500 gals	
2 Centrifuges	
1 Vacuum dryer	
2 Solvent extractors	
1 Colloid mill	
Spares etc	
TOTAL	£31,800



